EDUCATING SUSTAINABILITY

THROUGH PAPER RECYCLING IN SCHOOLS

CHUA YING SHIUN

B.A. (INDUSTRIAL DESIGN) HONS.

A THESIS SUBMITTED

FOR THE DEGREE OF MASTER OF ARTS

IN INDUSTRIAL DESIGN

DEPARTMENT OF ARCHITECTURE

NATIONAL UNIVERSITY OF SINGAPORE

2008

ACKNOWLEDGEMENTS

First of all, I would like to thank the National University of Singapore (NUS) for granting me a generous research scholarship that has helped me in my living and studying expenses for the past two years of research.

I would also like to take this opportunity to express my immense gratitude to all of the people who made this thesis possible:

I am most deeply indebted to my supervisor, Professor Teh Kem Jin for his excellent guidance and support through my years as a student in NUS. I would like to thank him especially for painstakingly reading and commenting on the numerous preliminary drafts of this thesis, as well as his many precious suggestions for improvement.

I am also thankful to my other tutors at the Department of Architecture in NUS, in particular, Dr. Yen Ching Chiuan, Dr. Christian Boucharenc, Dr. Tukka Keinonen, Dr. Tan Beng Kiang, Mr. Carlos Alberto Montana Hoyos and Ms Christiane English, for their helpful advice, comments, critique, and also for their warm-hearted encouragement.

On a final note, I recognize that I have been blessed with family members and friends who have been most encouraging and supportive towards me during the course of this research. And above all, I am eternally grateful to my Heavenly Father for the marvelous love He has bestowed upon me. His grace has sustained and kept me going throughout this journey.

TABLE OF CONTENTS

SUMMARY

The thesis research starts with the study on the growth in paper usage and the issue of sustainability. The study traces the evolution of men from early human settlements to modern civilization to understand the problem of over-consumption and the escalation of solid waste disposed globally. This raises the need for sustainability and waste minimization, in particular, through the process of recycling.

This thesis also documents the relevant historical developments on the invention of paper, as well as other inventions, such as the printing press, typewriter and photocopying machine, which have aided in promoting the extensive consumption of paper from the past to our present-day society.

The latter part of the study focuses on education as one of the most effective means to promote sustainability. The study explores how schools as educators can have better means of instilling in students the understanding and importance of environmental protection, conservation and sustainability.

The thesis concludes with a test project that demonstrates the feasibility of establishing a waste paper recycling system that could be incorporated as an education resource for schools in Singapore.

.

LIST OF TABLES

Chapter Two - Sustainability

Chapter Four - Paper

Chapter Five - Sustainability

Chapter Six - Sustainability And Recycling In Singapore's Schools

Chapter Seven – Design Conceptualization

Chapter Eight – Feasibility Study

LIST OF FIGURES

Chapter One – Solid Waste

Chapter Two - Sustainability

Chapter Three - Recycling

Chapter Four - Paper

Chapter Five - Singapore

Chapter Seven – Design Conceptualization

Chapter Eight – Feasibility Study

SECTION ONE – INTRODUCTION

"*WASTE IS A HUMAN CONCEPT. In nature nothing is wasted. Everything is part of a continuous cycle. Even the death of a creature provides nutrients that will eventually be reincorporated in the chain of life. The idea of waste springs from the perception of most material by-products of human activity as useless*."[1] The global waste crisis, the notion of sustainability and the need for recycling are all hot discussion topics of today. These three topics are also three of the key subjects that constitute to this research.

It is said that, "*Research is finding out something you don't know.*"[2] This first section comprises of four introductory chapters. These chapters are a consolidation of the background study done on the four key subjects of this thesis: solid waste, sustainability, recycling and paper, so as to present the need and purpose for this research.

[1] Rusi. C. Cooper, 'Introduction', in id., *War on waste: how to make millions from trash* (Singapore: Vocational Service Committee of the Rotary Club of Singapore, 1991), p. 1.

[2] Estelle M. Phillips and D. S. Pugh, 'Characteristics of research', in id., *How to get a Ph.D: a handbook for students and their supervisors* (2nd edn., Buckingham; Philadelphia: Open University Press, 1994), p. 45.

CHAPTER ONE - SOLID WASTE

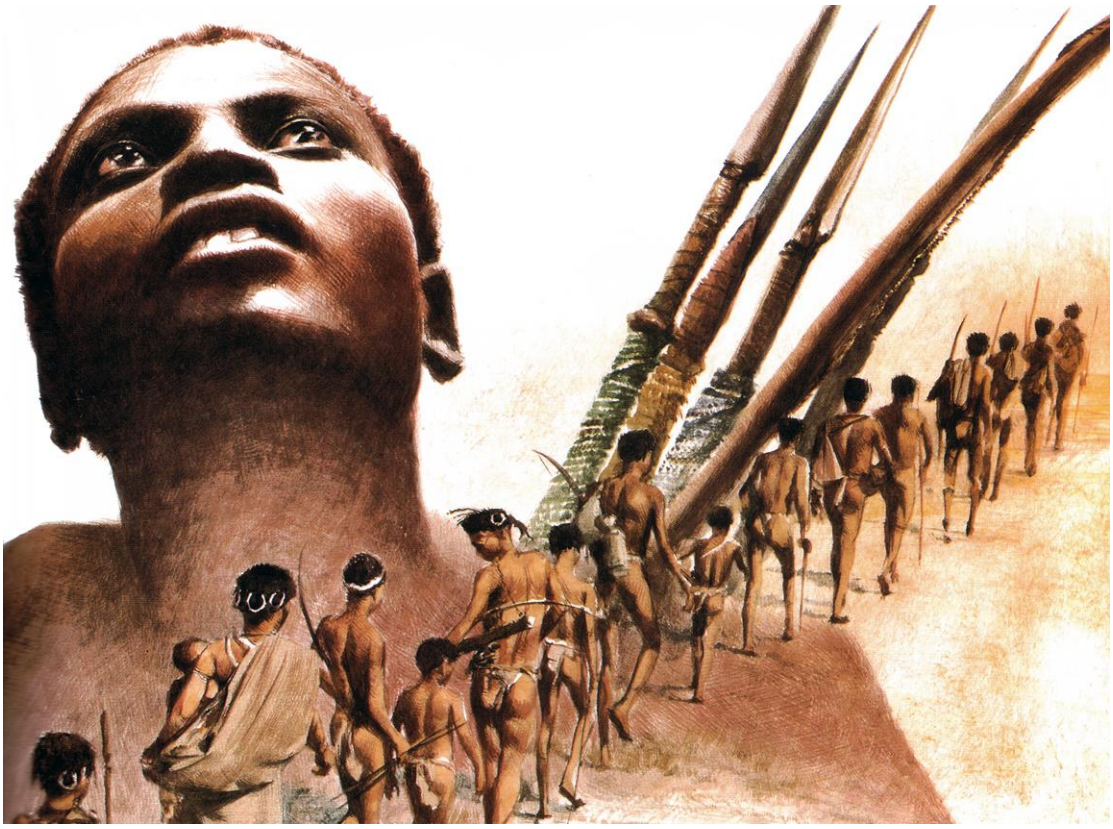


FIGURE 1-1 EARLY HUMANS IN THE HUNTER-GATHERERS LIFESTYLE

The hunter-gatherers move from area to area as each location is exhausted of games and fruits. Usually the women gather roots, leaves and fruits, while the men hunt.[3]

THE EVOLUTIONS IN HUMAN HISTORY AND THE RISE OF WASTE

According to archaeologists' and historians' findings and accounts, the early humans lived a hunters and gatherers lifestyle.[4] They lived by gathering wild edible plants, such as nuts, acorns, grains, berries and fruits. Fishing and hunting of wild animals

[3] Jacqueline Dineen, 'Hunting', in id., *Hunting, harvesting and home* (Surrey: Dragon's World, 1995), pp. 10-11.

[4] Michael Woods and Mary B. Woods, 'The Stone Age', in id., *Ancient agriculture: from foraging and farming* (Minneapolis, Minnesota: Lerner Publications, 2000), p. 13.

were also the other sources of food for them.[5] They fundamentally lived on what they were able to gather and hunt from the wild.[6] The early humans generally do not stay in one place for too long. After eating the food in one area, they would move on to another place for more food.[7]

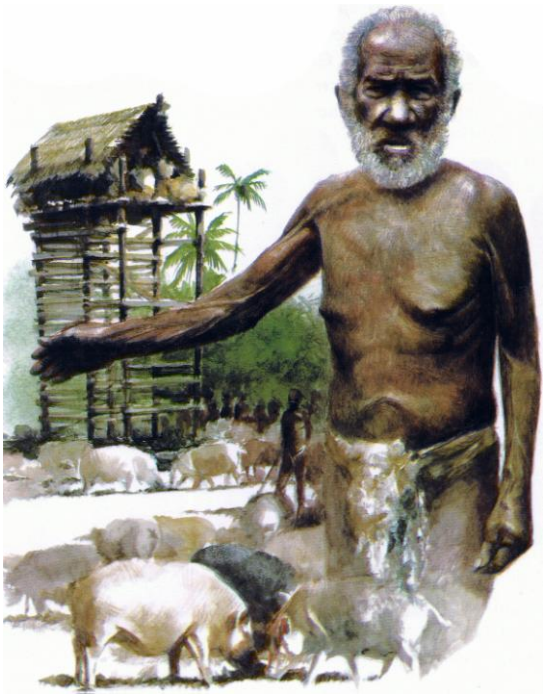


FIGURE 1-2 THE NEOLITHIC REVOLUTION – EARLY HUMANS MOVED INTO AGRICULTURE[8]

About fourteen thousand years ago at the end of the last Ice Age, a new lifestyle emerged.[9] Our ancient ancestors, who had previously lived by roaming around the land in search for food, began to settle down in one place and built their permanent homes.[10] Over time, they discovered that it is possible to help plants grow in the wild by tending and watering them. Similarly, they discovered that certain animals can be

---

5 Michael Woods and Mary B. Woods, 'The Stone Age', in id., *Ancient agriculture: from foraging and farming* (Minneapolis, Minnesota: Lerner Publications, 2000), pp. 13-14.

6 Daniel Gilpin, 'Hunting and gathering', in id., *Food and clothing* (New York: Facts On File, 2004), p. 6.

7 Jacqueline Dineen, 'Hunting', in id., *Hunting, harvesting and home* (Surrey: Dragon's World, 1995), pp. 10-11.

8 Jacqueline Dineen, 'Forced gifts and feasts', in id., *Hunting, harvesting and home* (Surrey: Dragon's World, 1995), p. 75.

9 British Broadcasting Corporation, 'The Neolithic Revolution - How farming changed the world', *British Broadcasting Corporation (BBC) – h2g2* [website], published online 05 Mar. 2004, <http://www.bbc.co.uk/dna/h2g2/A2054675>, accessed 16 Jan. 2008.

10 Daniel Gilpin, 'Farming takes hold', in id., *Food and clothing* (New York: Facts On File, 2004), p. 1.

herded or kept in fenced areas.[11] As a result, humans moved away from their former hunting and gathering way of life, and moved into agriculture – the domestication of plants and animals.[12] Thus, agriculture took root and a new era was ushered in, the Neolithic Era.[13]

FIGURE 1-3 AGRICULTURE IS SOMETIMES SAID TO LEAD TO CIVILIZATION

Papyrus and other agricultural crops were vital to the development of Egyptian civilization.[14]

The domestication of plants and animals brought to mankind a more reliable source of food. In fact, agriculture brought to mankind more than just food. For instance, the fibers from plants and the skins from animal became useful materials in clothes making. Domesticated animals like horses, cattle and camels became useful transportation mediums as well.[15] Dr. Michael Woods, an award-winning Washington,

---

11 Cathryn J. Long, 'How agriculture began', in id., *The agriculture revolution* (San Diego, California: Lucent Books, 2004), p. 10.

12 Michael Woods and Mary B. Woods, 'A changing society', in id., *Ancient agriculture: from foraging and farming* (Minneapolis, Minnesota: Lerner Publications, 2000), pp. 19-20.

13 British Broadcasting Corporation, 'The Neolithic Revolution - How farming changed the world', *British Broadcasting Corporation (BBC) – h2g2* [website], published online 05 Mar. 2004, <http://www.bbc.co.uk/dna/h2g2/A2054675>, accessed 16 Jan. 2008.

14 Alan K. Bowman, 'Egypt, ancient', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/180468/ancient-Egypt/22283/Introduction-to-ancient-Egyptian-civilization>, accessed 18 Jan. 2008.

15 Cathryn J. Long, *op. cit.*

D.C. based science and medical writer, together with his wife, described this in one of their books: "*Agriculture freed people from the need to spend every waking hour searching for food. With the extra time, people could build villages and cities; create literature, laws, and works of art; and invent new forms of technology to improve their lives.*"[16]

However, in the late 1970, Mark Cohen, an archaeologist, first suggested that agriculture was born of desperation.[17] Professor Jared Diamond from the University of California, Los Angeles (UCLA) in one of his publications, described that, "*As population densities of hunter-gatherers slowly rose at the end of the ice ages, bands had to choose between feeding more mouths by taking the first steps toward agriculture, or else finding ways to limit growth. Some bands chose the former solution, unable to anticipate the evils of farming, and seduced by the transient abundance they enjoyed until population growth caught up with increased food production. Such bands outbred and then drove off or killed the bands that chose to remain hunter-gatherers, because a hundred malnourished farmers can still outfight one healthy hunter. It's not that hunter-gatherers abandoned their life style, but that those sensible enough not to abandon it were forced out of all areas except the ones farmer didn't want.*"[18]

---

[16] Michael Woods and Mary B. Woods, 'A changing society', in id., *Ancient agriculture: from foraging and farming* (Minneapolis, Minnesota: Lerner Publications, 2000), pp. 19-20.

[17] The Economist Newspaper Limited, 'Hunter-gatherers: noble or savage?', *The Economist* [website], published online 19 Dec. 2007, <http://www.economist.com/displaystory.cfm?story_id=10278703>, accessed 23 Jan. 2008.

[18] Jared Diamond, 'The worst mistake in the history of the human race', *Discover Magazine*, May 1987, pp. 64-66.

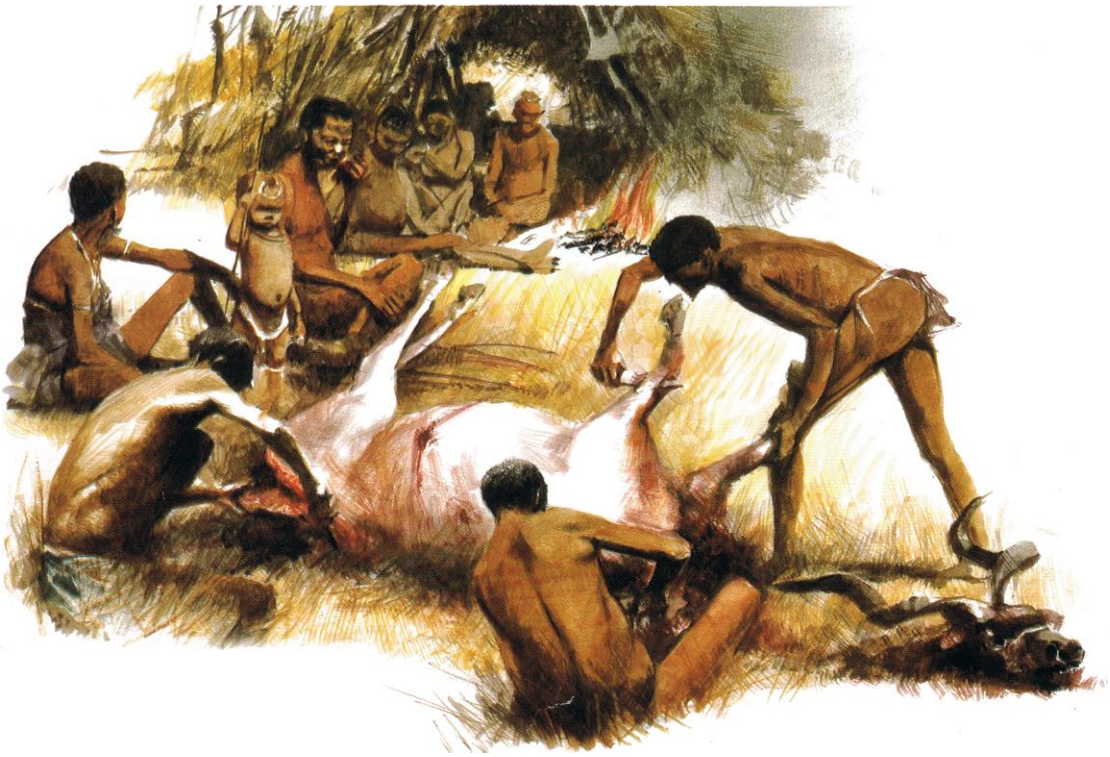


FIGURE 1-4 HUNTER-GATHERERS' STRONG BELIEFS ABOUT SHARING THE SPOILS

The men go out to hunt for animals, which will then be shared fairly between all the people among the group.[19]

Professor Diamond added that, "*Archaeologists studying the rise of farming have reconstructed a crucial stage at which we made the worst mistake in human history. Forced to choose between limiting population or trying to increase food production, we chose the latter and ended up with starvation, warfare, and tyranny. Hunter-gatherers practiced the most successful and longest lasting lifestyle in human history. In contrast, we're still struggling with the mess into which agriculture has tumbled us, and it's unclear whether we can solve it.*"[20] Indeed, Professor Diamond highlighted that agriculture, on a positive note, has unquestionably brought to us a

[19] Jacqueline Dineen, 'Dividing the spoils', in id., *Hunting, harvesting and home* (Surrey: Dragon's World, 1995), p. 18.

[20] Jared Diamond, 'The worst mistake in the history of the human race', *Discover Magazine*, May 1987, pp. 64-66.

more abundant and variety of food, better tools and material goods, as well as the longest and healthiest lives in history.[21]

However, agriculture has also on the other hand brought us health and waste accumulation issues. As agriculture encourages people to gather together and form settled societies, this also led to an easier spread of parasites and infectious diseases. It is believed that epidemics are less likely to take hold in the earlier population, as they were scattered in small bands and constantly shifting camps.[22] From an ecological perspective as well, because the early hunter-gatherers do not stay put in one place for a long time, the amount of waste they accumulated are generally insignificant. However, as humans began to settle in permanent communities with higher concentrations of waste-producing individual and activities, the need for waste management became clear.[23]

Nonetheless, the waste situation during the agricultural era has yet to become a concern for the environment as of today, as manufactured goods were still costly and difficult to obtain up until the eighteenth century. Prudent consumption was the way of life. Commodities were most often tended and mended to last as long as possible. It is accounted that the discard materials were primarily organic discards, such as food scraps, manure and human wastes, and they were most often gathered and reused by farmers to fertilize their field. This practice in fact is marked as the earliest form of recycling.[24]

---

[21] Jared Diamond, 'The worst mistake in the history of the human race', *Discover Magazine*, May 1987, pp. 64-66.

[22] *Ibid.*

[23] Joseph A. Ruiz, Jr., 'The beginning', in Herbert F. Lund (ed.), *The McGraw-Hill recycling handbook* (2nd edn., New York: McGraw-Hill, 2001), pp. 1.1-1.2.

[24] Heather Rogers, 'Rubbish past', in id., *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005), pp. 29-30.

FIGURE 1-5 THE EARLIEST FORM OF RECYCLING

A nineteenth century painting of a farmer spreading manure to fertilize the soil and increase his crop yield.[25]

Waste situation began to change dramatically as the Industrial Revolution set off in Europe in the eighteenth century.[26] Brenda Stalcup in her book explains that the Industrial Revolution, in the most basic terms, "*refers to the changes that take place when a primarily agricultural economy begins to shift to the mechanized manufacturing of goods on a large scale*".[27] The advancement in technologies led to greater production and distribution of goods.[28] For instance, the introduction of assembly line by Henry Ford, founder of Ford Motor Company,[29] in 1913 ushered in an age of full-scale mass production.[30] And ever since then, goods began to be manufactured in large quantities through the machinery production.[31]

---

25 Cathryn J. Long, 'In this nineteenth-century painting, a farmer spreads manure to fertilizer the soil and increase his crop yield', in id., *The agriculture revolution* (San Diego, California: Lucent Books, 2004), p. 39.

26 Eric Pawson, 'The causes of the Industrial Revolution in Britain', in Brenda Stalcup (ed.), *The industrial revolution* (San Diego, California: Greenhaven Press, 2002), p. 29.

27 Brenda Stalcup (ed.), 'A brief history of the industrial revolution', in id. (ed.), *The industrial revolution* (San Diego, California: Greenhaven Press, 2002), p. 11.

28 Gray Cross and Rick Szotak, 'From cottage to factory in Britain', in Brenda Stalcup (ed.), *The industrial revolution* (San Diego, California: Greenhaven Press, 2002), p. 64.

29 Asa Briggs (ed.), 'Ford, Henry', in id. (ed.), *Who's who in the twentieth century* (Oxford: Oxford University Press, 1999), p. 208.

30 Barbara Cady and Jean-Jacques Naudet, 'Henry Ford', in id., *Icons of the twentieth century: 200 men and women who have made a difference* (New York: The Overlook Press, 1998), p. 116.

31 Ray Batchelor, 'Introduction', in id., *Henry Ford, mass production, Modernism and design* (Manchester; New York: Manchester University Press, 1994), p. 2.

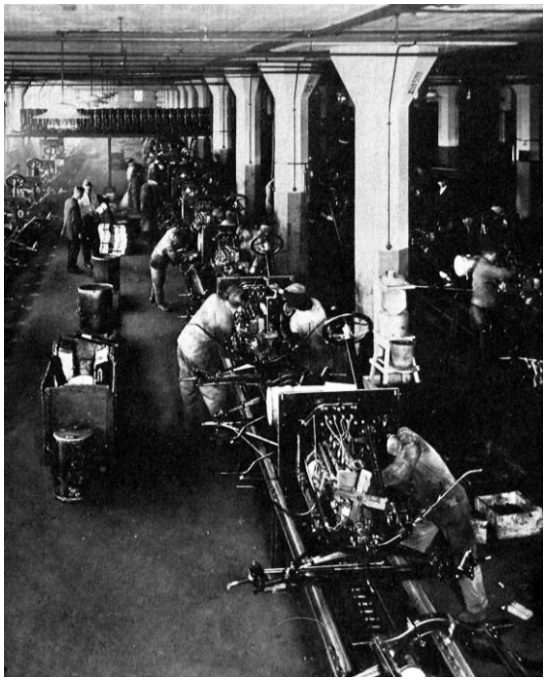


FIGURE 1-6 THE SPREAD OF THE FACTORY SYSTEM DURING THE INDUSTRIAL REVOLUTION

The assembly line system in Ford's Highland Park factory.[32]

American department-store entrepreneur, philanthropist and social reformer, Edward A. Filene's in his article, 'Mass Production Makes A Better World', states that, "*mass production can produce consumers by creating buying power*".[33] Filene explains that, "*Because the production per man is high, it is possible to pay high wages. Furthermore, when many articles are made by each worker under scientific mass methods the difference between a high wages and a low wage is relatively small part of the cost of each article. Then mass producers discover that the greatest total profits are made from the smallest practical profit per unit, because only by selling cheaply can the price be brought within the reach of the masses of consumers.*"[34] What Filene wrote is indeed true for Ford. It is said that even though Ford instituted the industrial mass production, what really mattered to him was actually mass consumption. Ford figured that if he could offer his factory workers with sufficient

[32] David A. Hounshell, 'The Ford Motor Company & the rise of mass production in America', in id., *From the American system to mass production 1800-1932: the development of manufactured technology in the United States* (Baltimore: Johns Hopkins University Press, 1984), p. 257.

[33] Edward A. Filene, 'Mass Production Makes a Better World' (1929), in Josh Sakolsky (ed.), *Critical perspectives on the Industrial Revolution* (New York: The Rosen Publishing Group, 2005), p. 143.

[34] *Ibid.*, pp. 143-144.

income and produced more cars in less time for less money, everyone would buy them.[35]

Heather Rogers however describes in her book, 'Gone Tomorrow: the hidden life of garbage' that, "*The advent of what is often called Fordism – mass assembly-line production coupled with mass standardized consumption and the mass psychology that goes with both – created a tidal wave of trash, and it did so in three distinct ways. First, the new Fordist economy used less recycled inputs from household waste handled by independent junk traders; instead, scrap came from consortiums of large materials handlers. Second, it built new forms of waste into both commodities and the production process, in part because these cut labor time and externalized cost, thereby boast profits. And third, the new economic regime created and demanded unprecedented levels of consumption, the main by-product of which was garbage.*"[36]

The market however became increasingly saturated shortly within the first decade after the World War II, as most of the consumers believed that they have already gotten all that they needed. The manufacturers recognized that they needed a new plan in order to sell more. Their answer was found in what is known today as, 'Built-in Obsolescence', where the manufacturers intentionally make commodities wore out faster than necessary.[37] As a matter of fact, many products were even designed to be thrown-away after one use.[38] In Sally Lee's book, 'The Throwaway Society', the author described, "*…billion disposable diapers a year to mountains of computer*

---

[35] Lee Iacocca, 'Henry Ford', in TIME/CBS News (ed.), *People of the Century* (New York: Simon & Schuster, 1999), p. 37.

[36] Heather Rogers, 'The golden age of waste', in id., *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005), pp. 103-105.

[37] *Ibid.*

[38] Lester W. Milbrath, 'Thrownaway mentality/society', in Robert Paehlke (ed.), *Conservation and environmentalism: an encyclopedia* (New York: Garland Publishing, 1995), p. 624.

printouts and masses of Styrofoam food containers…Our trash cans are stuffed with paper napkins, towels, and tablecloths, along with disposable pens, razors, and even cameras and contact lenses. With more people in the work force, frozen and carry-out foods (along with their disposable packaging) have replaced many home-cooked meals…It's not only the products themselves that create the problem; it's also the packaging those products come in. Almost everything we buy come in cardboard boxes, plastic or paper bags, plastic or Styrofoam cartons, glass bottles and jars, or metal containers. This packaging alone makes up about one-third of the household waste in our waste stream. Much of it is needed to keep the products sanitary and in good condition, but some of it is unnecessary."[39] Indeed, we have today become hooked on the convenience of disposable items. Needless to say, as a result of this, our refuse output skyrocketed.[40]

In 2000, the world produced 12.6 billion tons of waste (i.e. more than 2 tons from every person). It is projected that by 2050, we will be producing 26.7 billion tons of waste each year, nearly 3 tons per person.[41] One of the main factors to the escalation of waste is due to our rapid growing world population, from 220 million to 2.8 billion over the twentieth century.[42] The United Nations also announced its projection that the world population expected to reach 9.1 billion in 2050.[43] Therefore, even if the amount of waste that each person generated each day remains the same, there would still be a huge increase in waste generated, just because there would be

---

[39] Sally Lee, 'Reasons of a growing problem', in id., *The throwaway society* (New York: Franklin Watts, 1990), pp. 14-15.

[40] Heather Rogers, 'The golden age of waste', in id., *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005), pp. 103-105.

[41] Christiane Dorion, 'Choking on waste', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 4.

[42] United Nations Population Fund, 'Peering into the dawn of an urban millennium', in id., *State of World Population 2007: Unleashing the Potential of Urban Growth* (New York: United Nations Population Fund, 2007), p. 1.

[43] United Nations, 'World population to increase by 2.6 billion over next 45 years, with all growth occurring in less developed regions', *United Nations* [website], published online 24 Feb. 2005, <http://www.un.org/News/Press/docs/2005/pop918.doc.htm>, accessed 07 Feb. 2008.

more people generating the waste.[44] However, just like Christiane Dorion described in her book: "*The problem is that we are now producing more waste than can be absorbed by our natural environment*".[45]

[44] Sally Lee, 'Reasons of a growing problem', in id., *The throwaway society* (New York: Franklin Watts, 1990), pp. 14-15.

[45] Christiane Dorion, 'Choking on waste', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 5.

CHAPTER TWO - SUSTAINABILITY

FIGURE 2-1 THE 1992 UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT

The largest gathering of 117 world leaders, in Rio de Janeiro, Brazil, to reconcile worldwide economic development with protection of the environment.[46]

The waste crisis is a global issue that requires a global response.[47] Nations worldwide have come together to agree on clear directions in tackling with the waste issue.[48] The Agenda 21 is a global action plan for the 21st century, adopted by 178 nations at the United Nations Conference on Environment and Development (UNCED), also commonly known as the Earth Summit, held in Rio de Janeiro, Brazil

---

46 Encyclopedia Britannica, Inc., 'United Nations Conference on Environment and Development', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/616390/United-Nations-Conference-on-Environment-and-Development>, accessed 11 Feb. 2008.

47 Christiane Dorion, 'One World', in id., *Waste disposal* (London: Franklin Watts, 2007), pp. 42-43.

48 *Ibid.*

in 1992.[49] The Agenda 21 devoted three specific chapters in addressing our global waste issue, affirming the need of sustainability, so as to bring an end to our excessive use of the world's natural resources in an international level.[50]

THE CONCEPT OF SUSTAINABILITY

Sustainability, in layman's term, simply means 'the ability to sustain', and to sustain is "*to cause or allow something to continue for a period of time*".[51] The origin to the concept of sustainability remains unclear till this day. The Israelis claim the issues of sustainability have been a part of their Jewish thought and legislation for millennia.[52] Under the Torah mandate, the Orthodox Jews observe a sabbatical year for their land in every seventh year.[53] The farmers would scrupulously desert their fields at the end of each six-year period, and left their land to fallow for a year.[54] It is believed that by letting the land rest for a year strengthens it, and will provide a better yield in the following year.[55] Dr. Steven Hall from the Louisiana State University in his writing, 'Towards a theology of sustainable agriculture', also agrees that by allowing the agriculture land to rest and recover is a longstanding biblical vision of sustainability in agriculture.[56]

---

49 Simon Dresner, 'The Earth Summit', in id., *The principles of sustainability* (London; Sterling, Virginia: Earthscan Publications, 2002), pp. 38-39.

50 Christiane Dorion, 'An agenda for the 21st century', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 43.

51 *Cambridge Advanced Learner's Dictionary*, s.v. 'sustain'.

52 Samuel Chayen, 'Sustainable development in Judaism', *Israel Ministry of Foreign Affairs* [website], published online 10 Aug. 2002, <http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2002/8/Sustainable%20Development%20in%20Judaism>, accessed 13 Feb. 2008.

53 Steven Erlanger, 'As farmers and fields rest, a land grows restless', *The New York Times* [website], published online 08 Oct. 2007, <http://www.nytimes.com/2007/10/08/world/middleeast/08shmita.html>, accessed 14. Feb. 2008.

54 Time Inc., 'Shmita: 5712', *Time Magazine* [website], published online 10 Oct. 1952, <http://www.time.com/time/magazine/article/0,9171,817136,00.html?iid=chix-sphere>, accessed 14 Feb. 2008.

55 Samuel Chayen, *op. cit.*

56 Steven Hall, 'Towards a theology of sustainable agriculture', in Roman J. Miller (ed.), *Perspectives on Science and Christian Faith*, 54/2 (2002), pp. 103-107.

FIGURE 2-2 HANS CARL VON CARLOWITZ'S SYLVICULTURA OECONOMICA

The word 'Sustainability' ('Nachhaltigkeit' in German) was first introduced in Hans Carl von Carlowitz's 'Sylvicultura Oeconomica' in 1713.[57]

Some however believe the concept of sustainability was first presented in Germany by Mr. Hans Carl von Carlowitz about three hundred years ago. In the beginning of the eighteenth century, Carlowitz, who was a mining supervisor in Saxon Silver City – Freiberg, Germany,[58] saw that though the Saxon silver mining industry was flourishing, it was also devouring enormous quantities of wood to produce charcoals for the smelting furnaces. And when more and more forests were converted to farmlands because it brings quick profits, the timber prices began to rise at a

[57] Wikimedia Foundation, Inc., 'Hans Carl von Carlowitz', *Wikipedia* [website], updated 19 Feb. 2008, <http://en.wikipedia.org/wiki/Hans_Carl_von_Carlowitz>, accessed 19 Feb. 2008.

[58] Ulrich Grober, 'Der Erfinder der Nachhaltigkeit [The inventor of sustainability]', *Die Ziet*, 48 (1992), <http://www.zeit.de/1999/48/Der_Erfinder_der_Nachhaltigkeit>, accessed 19 Feb. 2008.

phenomenal rate.[59] Carlowitz recognized that the existence of the Saxon silver mining industry could be threatened if all the forests in Freiberg were to be removed. This led Carlowitz to present in his book, 'Sylvicultura Oeconomica' in 1713, the need of developing the conservation and cultivation of wood in order to have a lasting supply of wood. His aim was to save the society from economic and social disaster if wood were to run out one day.[60]

The World Council of Churches (WCC) also laid its claims that the concept of sustainability was first being articulated at a WCC conference gathering of scientists, theologians and economists in Bucharest, Romania in 1974.[61] In response to the global population growth causing great depletion of the earth's natural resources, what emerged out of this Bucharest discussion was the articulation of the concept of sustainability.[62] The definition of sustainability from the conference is depicted as follows: "*For a short period in recent history some societies cultivated the dream of unlimited wealth, of overcoming poverty not primarily by sharing wealth but by increasing it so that there would be enough for all. Now we face a sobering return to reality. We begin to perceive that the future will require a husbanding of resources and a reduction of expectations of global economic growth. We do not expect that humanity can live as the most extravagant have been living, and we no longer believe that the spillover of wealth from the top will mean prosperity for all. There may be a divine irony in the fact that the very technological victories which once supported the vision of affluence, now – by their contribution to increasing*

---

59 Danzer Group, 'The history of sustainability', *Danzer Group* [website], <http://www.danzergroup.com/History-of-Sustainability.1601.0.html#>, accessed 20 Feb. 2008.

60 Seppo Vehkamäki, 'The concept of sustainability in modern times', *Sustainable use of renewable natural resources – from principles to practices*, 34/2.2 (2005), <http://www.mm.helsinki.fi/mmeko/tutkimus/SUNARE/pdf/22_Vehkamaki.pdf>, accessed 20 Feb. 2008.

61 David G. Hallman, 'Report on the World Summit on Sustainable Development (WSSD)', *World Council of Church* [website], published online 04 Sep. 2002, <http://www.oikoumene.org/?id=2538>, accessed 21 Feb. 2008.

62 *Ibid.*

consumption of resources, growing population, and pollution – are bringing an end to the dream of a carefree and affluent future. The goal must be a robust, sustainable society, where every individual can feel secure that his or her quality of life will be maintained or improved."[63]

Despite the different claims to the invention of sustainability, it is however commonly accepted that the notion of sustainability, as we know today, truly came to prominence in the 1980s.[64] In 1983, the General Assembly of the United Nations established a special independent body called the World Commission on Environment and Development (WCED). This commission chaired by the former Prime Minister of Norway, Dr. Gro Harlem Brundtland, published a report under the title, 'Our Common Future'.[65]

[63] Lukas Vicher, 'Climate change, sustainability and Christian witness - The Churches and Climate Change' *The Ecumenical Review*, Apr. (1997), <http://findarticles.com/p/articles/mi_m2065/is_n2_v49/ai_19496267>, accessed 21 Feb. 2008.

[64] Simon Dresner, 'What is sustainability', in id., *The principles of sustainability* (London; Sterling, Virginia: Earthscan Publications, 2002), pp. 1-2.

[65] Sheila Jasanoff, 'Our Common Future', in Robert Paehlke (ed.), *Conservation and environmentalism: an encyclopedia* (New York: Garland Publishing, 1995), pp. 504-505.

FIGURE 2-3 DR. GRO HARLEM BRUNDTLAND

Dr. Gro Harlem Brundtland, Director-General Emerita of the World Health Organization and former Prime Minister of Norway, established and chaired the World Commission on Environment and Development in 1983.[66]

Simon Dresner, a research fellow at United Kingdom's Policy Studies Institute, describes in his book that, "*The central recommendation of this document, usually known as the Brundtland report, was that the way to square the circle of competing demands for environmental protection and economic development was through a new approach: "sustainable development'.*"[67] The Commission describes that the ability to make development sustainable is by ensuring that it meets *"the needs of the present without compromising the ability of future generations to meet their own needs.*"[68] The goal of sustainable development is to create a new era of economic

[66] St. Olaf College, 'Gro Harlem Brundtland', *The 16th annual Nobel Peace Prize Forum* [website], <http://www.stolaf.edu/nppf/2004/media/brundtland-hi.jpg>, accessed 03 Mar. 2008.

[67] Simon Dresner, 'What is sustainability', in id., *The principles of sustainability* (London; Sterling, Virginia: Earthscan Publications, 2002), pp. 1-2.

[68] World Commission on Environment and Development, 'Sustainable Development', in id., *Our common future* (Oxford: Oxford University Press, 1987), p. ES-7.

growth in a way that it eliminates poverty and yet extends to everyone the opportunity to fulfill his or her aspirations for a better life.[69]

In the Brundtland report, it says, "*If needs are to be met on a sustainable basis the Earth's natural resource base must be conserved and enhanced. Major changes in policies will be needed to cope with the industrial world's current high levels of consumption, the increases in consumption needed to meet minimum standards in developing countries, and expected population growth. However, the case for the conservation of nature should not rest only with development goals. It is part of our moral obligation to other living beings and future generations.*"[70] It also stated that, "*Even the narrow notion of physical sustainability implies a concern for social equality between generations, a concern that must logically be extend to equity with each generation*".[71]

[69] Eugene R. Wahl and E. Shrdlu, 'Sustainable development', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 1004-1005.

[70] World Commission on Environment and Development, 'Towards Sustainable Development', in id., *Our common future* (Oxford: Oxford University Press, 1987), p. 57.

[71] *Ibid.*, p. 43.

FIGURE 2-4 THE 2002 WORLD SUMMIT ON SUSTAINABLE DEVELOPMENT

A ten-years-after sequel to the Earth Summit in 1992.[72]

In 2002, a more fully developed paradigm of sustainable development was endorsed at the Word Summit on Sustainable Development in Johannesburg, South Africa.[73] It states that, "*sustainable development is built on three 'interdependent and mutually reinforcing pillars' – economic development, social development and environmental protection – which must be established 'at local, national, regional and global levels.'*"[74]

[72] United Nations Department of Public Information Photo Library, 'Johannesburg Summit: Photos - Press Conference: Healthy Environments for Children Initiative 01 September 2002', *United Nations: Johannesburg Summit 2002* [website], updated 23 Mar. 2003, <http://www.un.org/events/wssd/photos/0238.jpg>, accessed 10 Mar. 2008.

[73] United Nations Division for Sustainable Development, 'Johannesburg Declaration on Sustainable Development', *United Nations Division for Sustainable Development* [website], updated 15 Dec. 2004, <http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POI_PD.htm>, accessed 11 Mar. 2008, <http://portal.unesco.org/education/en/files/30363/11035294683brief_Concept_of_ESD.pdf/brief%2BConcept%2Bof%2BESD.pdf>, accessed 10 Mar. 2008.

[74] *Ibid.*

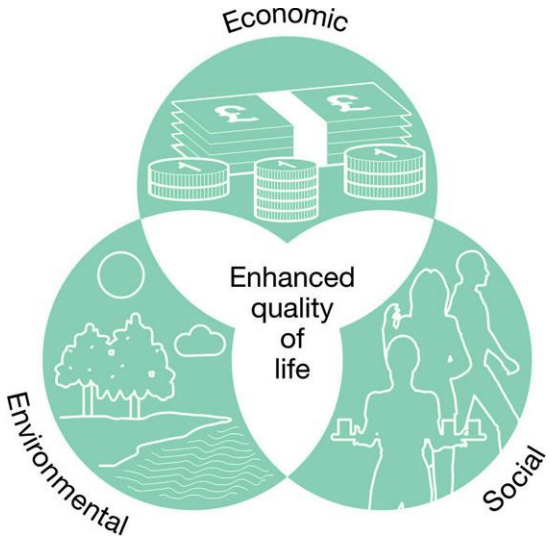


FIGURE 2-5 THE THREE DIMENSIONS OF SUSTAINABILITY[75]

TABLE 2-1 THE COMPARISON OF SOCIAL, ECONOMIC, AND ENVIRONMENTAL SUSTAINABILITY[76]

Social Sustainability	**Economic Sustainability**	**Environmental Sustainability**
Cohesion of community, cultural identity, diversity, solidarity, tolerance, humility, compassion, patience, forbearance, fellowship, cooperation, fraternity, love, pluralism, commonly accepted standard of honesty, laws, discipline, etc. constitute the aspects of social capital least subject to rigorous measurement, but essential for social sustainability.	Economic capital should be stable. The widely accepted definition of economic sustainability is maintenance of capital, or keeping capital intact. The amount consumed in a period must maintain the capital intact because only the interest rather than capital has to be consumed.	Although Environmental Sustainability (ES) is needed by humans and originated because of social concerns, ES itself seeks to improve human welfare by protecting the sources of raw materials used for human needs, and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans.
This moral capital requires maintenance and replenishment by shared	Economics has rarely been concerned with natural capital (e.g., intact forests, healthy air, stable soil fertility). To the traditional economic	Humanity must learn to live within the limitations of the biophysical environment. ES signifies

[75] Tata Steel UK Limited, 'Three dimensions', *Colorcoat-Online* [website], <http://www.colorcoat-online.com/file_source/StaticFiles/Colorcoat%20Online/Images/three_dimensions_800.jpg>, accessed 12 Mar. 2008.

[76] Maurizio G. Paoletti, 'Comparsion of social, economic, and environmental sustainability (Modified from different sources, especially the work of Goodland and Pimentel, 1998)', in Masae Shiyomi and Hiroshi Koizumi (eds.), *Structure and function in agroecosystem design and management* (Boca Raton, Florida: CRC Press, 2000), p. 19.

values and equal rights, and by community, religious, and cultural interactions. Without such care it depreciates as surely as would physical capital. Human and social capital, investment in education, health, and nutrition of individuals is now accepted as part of economic development, but the creation and maintenance of social capital as needed for social sustainability is not yet adequately recognized.	criteria of allocation and efficiency must now be added a third, that of scale. The scale criterion would constrain throughput growth – the flow of material and energy (natural capital) from environmental sources to sinks. Economic values are restricted to money; valuing the natural intergenerational capital, such as soil, water, air, biodiversity, is problematic.	that natural capital must be maintained, both as a provider of inputs of sources and as a sink for wastes. This requires that the scale of the human economic subsystem be held to within the biophysical limits of the overall ecosystem on which it depends. ES needs sustainable consumption by a stable population. On the sink side, this translates into holding waste emission within the assimilative capacity of the environment without impairing it. On the source side, harvest rates of renewable must be kept within regeneration rates.

EDUCATION FOR SUSTAINABILITY

The United Nations Educational, Scientific and Cultural Organization (UNESCO) believes that, "*Ultimately, sustainable development will require an education that not only continues throughout life, but is also as broad as life itself, an education that serves all people, draws upon all domains of knowledge and seeks to integrate learning into all of life's major activities.*"[77] It is also noted in the Agenda 21 that, "*Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues.*"[78] Thus, in December 2002, the United Nations General Assembly declared a 'United Nations

[77] United Nations Educational, Scientific and Cultural Organization, 'Educating for a Sustainable Future: A Transdisciplinary Vision for Concerted Action', *United Nations Educational, Scientific and Cultural Organization* [website], published online 19 Aug. 1998, <http://unesdoc.unesco.org/images/0011/001106/110686eo.pdf>, accessed 17 Mar. 2008.

[78] United Nations Division for Sustainable Development, 'Agenda 21: Chapter 36', *United Nations Division for Sustainable Development* [website], updated 15 Dec. 2004, <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter36.htm>, accessed 17 Mar. 2008.

Decade of Education for Sustainable Development' from 2005 till 2014.[79] The goal is "*to promote education as the basis for a sustainable human society and to strengthen international cooperation toward the development of innovative policies, programs and practices of education for sustainable development (ESD).*" [80]

Education is widely agreed as the most effective means that the society possesses for confronting the challenges of the future and shaping the world of tomorrow.[81] Other than making people wiser, better informed, more knowledgeable, ethical, responsible, and capable to learn continuingly, education also has a responsibility to cultivate amongst the students the skill and attitude that allows everyone in both present and future generations to have a fair and equitable access to our earth's resources, and to have a decent quality of life that preserves the biologically diverse ecosystem that we are all dependable on.[82]

Research however shows that most young students have a very short vision of the future, ranging from days to weeks, depending on their economic background and other factors.[83] The challenge therefore lies in how to engage the students to take a long-term view into the future to understand the need for sustainability.[84]

---

79 United Nations Educational, Scientific and Cultural Organization, 'UN Decade of Education for Sustainable Development (2005-2014)', *United Nations Educational, Scientific and Cultural Organization* [website], published online 15 Apr. 2004, <http://portal.unesco.org/education/en/files/30367/11035296383brief_Decade_2005-14.pdf/brief%2BDecade%2B2005-14.pdf>, accessed 17 Mar. 2008.

80 *Ibid.*

81 United Nations Educational, Scientific and Cultural Organization, 'Educating for a Sustainable Future: A Transdisciplinary Vision for Concerted Action', *United Nations Educational, Scientific and Cultural Organization* [website], published online 19 Aug. 1998, <http://unesdoc.unesco.org/images/0011/001106/110686eo.pdf>, accessed 17 Mar. 2008.

82 University of New South Wales, 'Why educate for sustainability', in id., *Education for sustainability* (Sydney: University of New South Wales Publishing and Printing Services, 1999), p. 3.

83 Keith A. Wheeler, 'Thinking about and affecting the future', in Keith A. Wheeler and Anne Perraca Bijur (eds.), *Education for a sustainable future: a paradigm for hope for the 21st century* (New York: Kluwer Academic/Plenum Publishers, 2000), p. 3.

84 *Ibid.*

The Australian Commonwealth Government, for instance, is currently working with their national education systems and schools to implement sustainable school programs that implement the approaches to sustainability into education. The sustainable school programs focus on how schools manage resources such as energy and water, and how do they integrate the approaches to sustainability into the formal classroom curriculums and the informal curriculum of school operating procedures. The involvement of the school's local community is also a crucial element of the sustainable school programs. [85]

This is also the reason why many national governments institute recycling programs in school,[86] because recycling in schools is not only a good way to reduce waste at school, it is also an excellent way to inculcate the habit of recycling and a sustainable lifestyle amongst the students from young.

[85] Rob Gilbert (ed.), 'Towards the sustainable school', in id. (ed.), *Studying society and environment: a guide for teachers* (3rd edn., South Melbourne, Victoria: Thomson Learning Nelson, 2004), p. 194.

[86] Melanie Ostopowich, 'Does your school make too much trash', in id., *Waste: refuse, misuse, and reuse* (New York: Weigl Educational Publishers, 2004), p. 15.

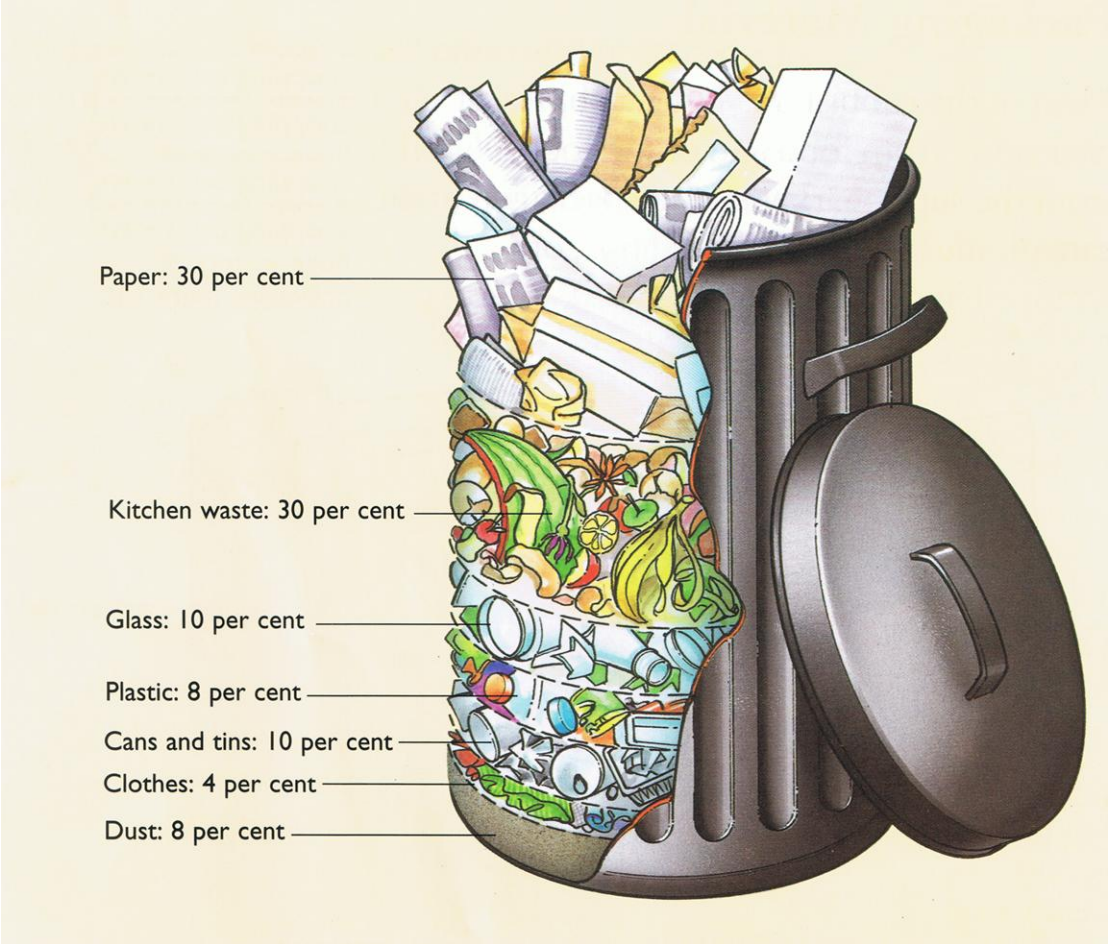


FIGURE 3-1 THE MAIN ITEMS OF HOUSEHOLD REFUSE THAT GET THROWN AWAY EACH WEEK[87]

It is believed that three-fourth of these disposed items can be recycled.[88]

Professor Lester W. Milbrath of the University at Buffalo, in his article 'Throwaway Mentality/Society', describes this: "*By succumbing to the allure of throwing away, we forgot (or never learned) that there is no 'away'. The first law of thermodynamics tells us that matter and energy can neither be created nor destroyed; they can only be*

[87] Angela Royston, 'Rubbish and waste', in id., *Recycling* (Hove, East Sussex: Wayland Publishers, 1998), p. 5.

[88] Rosie Harlow and Sally Morgan, 'Waste not, want not', in id., *Garbage and recycling* (2nd edn., Boston, Massachusetts: Kingfisher, 2001), p. 12.

transformed: everything has to go somewhere". Indeed all the waste that we throw away do not just disappear, they have to go somewhere.

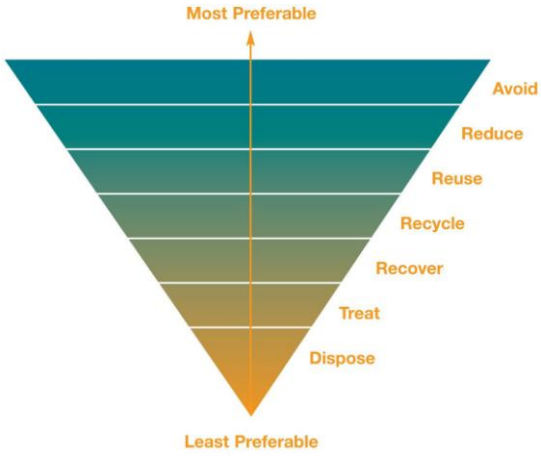


FIGURE 3-2 THE HIERARCHY OF WASTE MANAGEMENT[89]

WASTE MANAGEMENT

"*From an overall material consumption standpoint, excessive quantities of waste in society result from inefficient production processes on the industrial side, and low durability of goods and unsustainable consumption patterns on the consumer side. While total waste quantities are a reflection of the loss of resources…*", says Dr. Nicholas P. Cheremisinoff in his book, 'Handbook of solid waste management and waste minimization technologies'.[90] In promoting more sustainable use of our resources, solid waste management practices have gradually been implemented through policy guidelines at national levels in most of the industrialized countries around the world. Guidelines and directives to promote waste reduction and recovery are laid down according to the 'Waste Management Hierarchy'. Under the 'Waste

[89] Enterprise Ireland, 'Figure 1. Hierarchy of waste management', *Envirocentre.ie* [website], updated 25 Mar. 2008, <http://www.envirocentre.ie/includes/images/Waste%20Management%20hierarchy3.jpg>, accessed 26 Mar. 2008.

[90] Nicholas P. Cheremisinoff, 'Introduction', in id., *Handbook of solid waste management and waste minimization technologies* (Amsterdam; London: Butterworth-Heinemann, 2003), p. 1.

Management Hierarchy', waste prevention, reuse, recycling and energy recovery are designed to minimize the amount of waste left for the final, safe disposal.[91]

WHERE DOES OUR GARBAGE GO

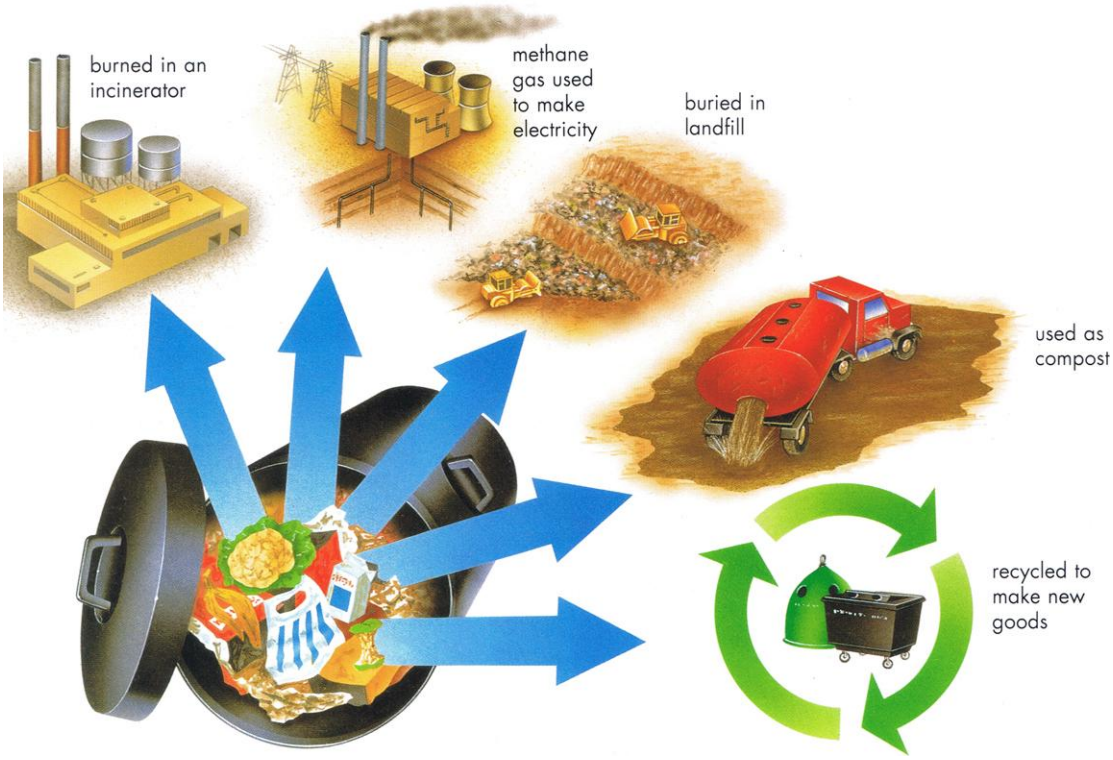


FIGURE 3-3 WHERE OUR GARBAGE GOES TO AFTER DISPOSAL[92]

LANDFILLS

Dumping our garbage in landfills has been the most traditional and cheapest means of disposing our waste for most industrialized countries.[93] A landfill is a designed structure built into or on top of the ground where the garbage trucks would dump

[91] Isa Baud, 'Markets, partnerships and sustainable development in solid waste management; raising the questions', in Isa Baud, Johan Post and Christine Furedy (eds.) *Solid waste management and recycling: actors, partnerships, and policies in Hyderabad, India and Nairobi, Kenya* (Dordrecht: Kluwer Academic Publishers, 2004), pp. 4-5.

[92] Rosie Harlow and Sally Morgan, 'Where does it go?', in id., *Garbage and recycling* (2nd edn., Boston, Massachusetts: Kingfisher, 2001), p. 6.

[93] Christiane Dorion, 'A trip to the landfill site', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 8.

their loads of collected waste.[94] The waste in the landfills is compacted and covered with a layer of dirt to decrease odor and discourage flies and other insects.[95] But, the problem with landfills is they take up land spaces, and as people generate more and more waste, the amount of available landfill space is lessening rapidly.[96] Furthermore, landfills also cause pollution as they produce gases, such as methane and carbon dioxide, which contribute to global warming.[97]

INCINERATION

Incineration refers to "*the burning of waste in a specially designed combustion chamber.*"[98] In many countries, such as Japan and Singapore, where land spaces are limited, a large proportion of their waste is burned in incineration. However, incineration remains a more expensive method of treating our solid waste. It could not compete with the vastly less expensive method of landfill dumping, as landfill dumping requires fewer and lesser skilled workers.[99] But, like landfills, incinerations can also cause environmental and health issues.[100] The primary problem with incineration is air pollution as the burning of solid waste produces carbon monoxide, sulfur dioxide and particulates containing heavy metals.[101]

COMPOSTING

Composting is another volume reduction technique to our disposed waste. However, not all waste can be composted. Only natural waste, such as leaves, grass clippings,

---

94 Christiane Dorion, 'A trip to the landfill site', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 8.
95 Linda Rehkopf, 'Solid waste landfilling', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), p. 972-973.
96 *Ibid.*
97 Christiane Dorion, 'The problem with landfills', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 9.
98 Linda Rehkopf, *op. cit.*
99 Heather Rogers, 'Burned out', in id., *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005), pp. 80-82.
100 Christiane Dorion, 'Up in smoke', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 10.
101 Linda Rehkopf, *op. cit.*

tree pruning and other organic material, can be collected separately and be reduced in volume through a natural composting process by micro-organism into rich natural fertilizers. Although composting is the easiest to practice on a small scale, its success has been hindered by a lack of markets and other applications in a larger scale.[102]

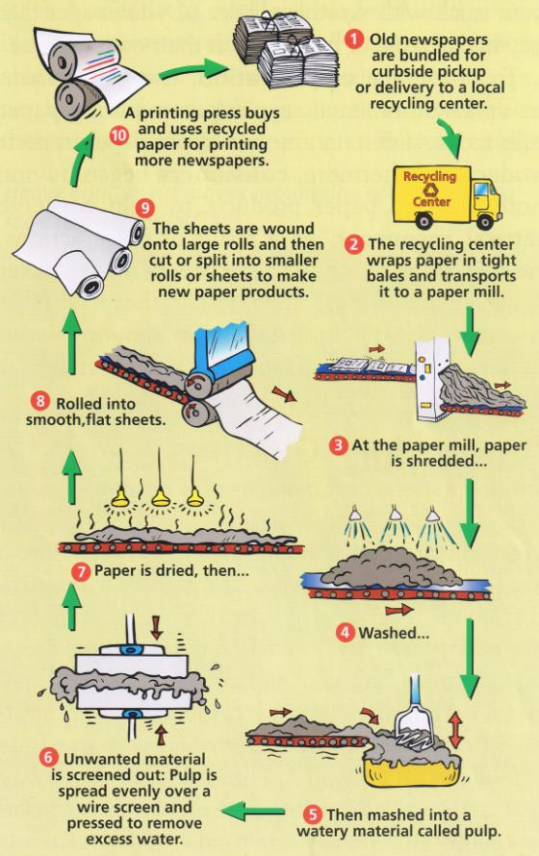


FIGURE 3-4 HOW NEWSPAPERS ARE RECYCLED[103]

RECYCLING

Recycling is a process by which unwanted waste - discarded materials from households, businesses, industries and agriculture[104] - are transformed into usable resources. It can involve turning old materials into a new version of the same item, or

[102] Joseph A. Ruiz, Jr., 'Composting' in Herbert F. Lund (ed.), *The McGraw-Hill recycling handbook* (2nd edn., New York: McGraw-Hill, 2001), p. 1.9.
[103] Eleanor J. Hall, 'How newspapers are recycled', in id., *Recycling* (Detroit, Michigan: KidHaven Press, 2005), p. 13.
[104] Teresa C. Donkin and Douglas, 'Solid waste', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 970-972.

into something entirely different.[105] One of the most familiar and long-established examples of recycling is the recovery of yesterday's old newspapers and reuse them as raw materials in the production of new paper products, such as toilet papers, shoe-boxes, or even a new sheets for tomorrow's newspapers.[106] Recycling is a significant way to keep large amount of our solid waste out of landfills and incineration, and also helps in conserving resources and energy.[107] Recycling also create new jobs and industries.[108]

The single most restrictive obstacle to recycling is probably human behavior.[109] In order to make the recycling system work at its best, it requires the consumers to extract recyclables, such as aluminum, paper, glass and plastic, from their refuse and to separate them into their various types, and thereafter bring them the recycling points or centers where they will be collected to be made into new products.[110] To close the loop, the consumers are also required to buy the recycled goods. In fact, there is a slogan used widely by recycling promoters that, "*You are not really recycling if you aren't buying recycled.*"[111] All these activities demand a huge behavioral change on both the consumers and the manufacturers.[112]

[105] Christiane Dorion, 'Recycling', in id., *Waste disposal* (London: Franklin Watts, 2007), p. 36.
[106] Jack McGinnis, 'Recycling', in Robert Paehlke (ed.), *Conservation and Environmentalism, an encyclopedia* (New York: Garland Publishing, 1995), p. 548.
[107] Linda Rehkopf, 'Solid waste recycling and recovery', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 974-975.
[108] Cynthia Fridgen, 'Recycling', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 862-864.
[109] Cynthia Fridgen, 'Waste management', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 1079-1080.
[110] Linda Rehkopf, *op. cit.*
[111] Eleanor J. Hall, 'Closing the recycling loop', in id., *Recycling* (Detroit, Michigan: KidHaven Press, 2005), pp. 30-22.
[112] Cynthia Fridgen, 'Waste management', in William P. Cunningham et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998), pp. 1079-1080.

FIGURE 3-5 THE RECYCLING SYMBOL

Recycling - Three steps in the loop.[113]

All of the waste collection and processing methods have their merits and limitations. There is not a single answer or solution to our waste management.[114] Governments, industries, communities and individuals all around the world are finding different ways to solve the problems of how to conserve resources, reduce pollution and waste, and protect our environment.[115] Nonetheless, recycling is still widely held, as the most environmentally desired solid waste management strategy.[116]

[113] Eleanor J. Hall, 'The Recycling Symbol: Three steps in the loop', in id., *Recycling* (Detroit, Michigan: KidHaven Press, 2005), p. 10.
[114] Joseph A. Ruiz, Jr., 'Summary' in Herbert F. Lund (ed.), *The McGraw-Hill recycling handbook* (2nd edn., New York: McGraw-Hill, 2001), p. 1.10.
[115] Kate Walker, 'Recycling, in id., *Recycle, reduce, reuse, rethink* (South Yarra, Victoria: Macmillan Education, 2007), p. 4.
[116] Joseph A. Ruiz, Jr., *op cit.*

CHAPTER FOUR - PAPER

Paper has become one of the most essential commodities in our modern world today.[117] The word 'paper' is derived from a plant called 'papyrus'.[118] Prior to the invention of paper, the ancient Egyptians first discovered a writing material made from a tall flowering freshwater reed known as the 'Cyperus papyrus'.[119]

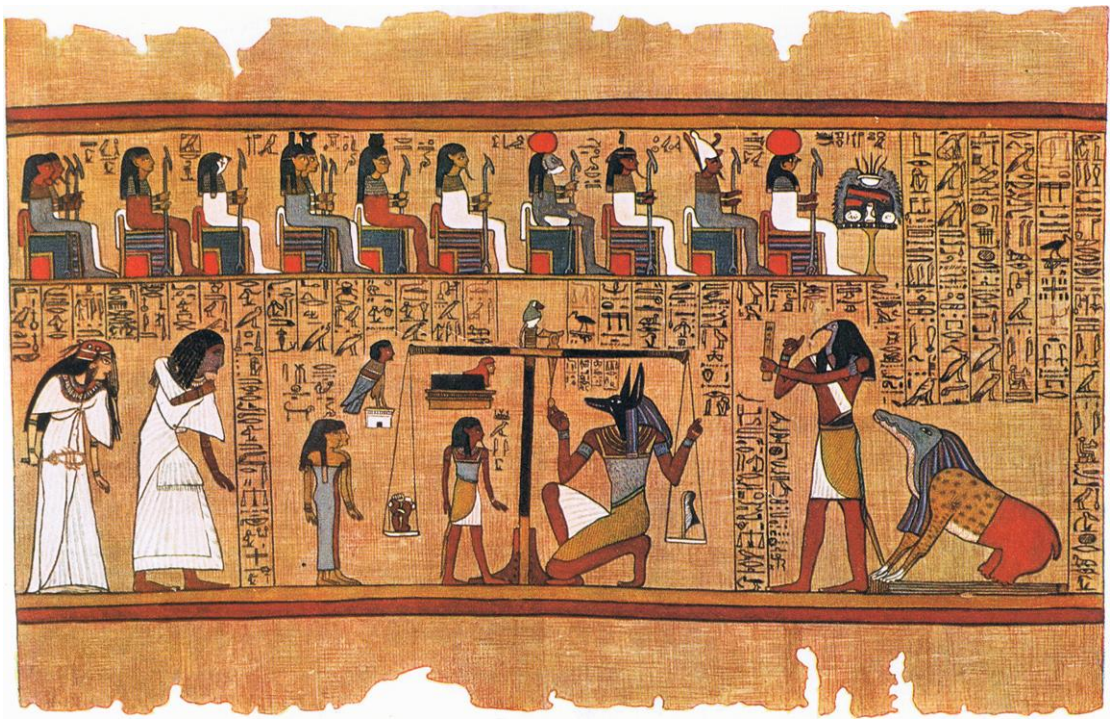


FIGURE 4-1 PAPYRUS

The chief writing material of ancient Egypt before the invention of paper[120]

[117] Library of Congress, 'The Beginnings in the Orient: China Korea, and Japan', in id., *Papermaking: art and craft; an account derived from the exhibition presented in the Library of Congress, Washington, D.C., and opened on April 21, 1968* (Washington, D.C.: Library of Congress, 1968), p. 8.

[118] Sophie Dawson, 'Ancient Precursors', in id., *The art and craft of papermaking* (London: Quarto, 1992; repr. Asheville, North Carolina: Lark Books, 1996), pp. 8-9.

[119] Richard Parkinson and Stephan Quirke, 'Natural history and manufacture', in id., *Papyrus* (Austin, Texas: University of Texas Press, 1995), p. 9.

[120] John Plowman, 'Papermaking: unfolding the story', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 7.

These papyrus plants, which were flourishing in the marshes along Nile River in the time of ancient Egypt,[121] have a triangular-shaped cross-section that is as thick as a man's wrist.[122] The ancient Egyptians cut the inner core of the papyrus stem into many thin longitudinal strips and laid them side-by-side, slightly overlapping. Thereafter, they laid another layer across the first in a crosshatch pattern, and cover both layers with mud or paste. Once the mud or paste is dried, the strips of papyrus turn stiff and are bonded together, and as a result become a material that people could write on.[123]

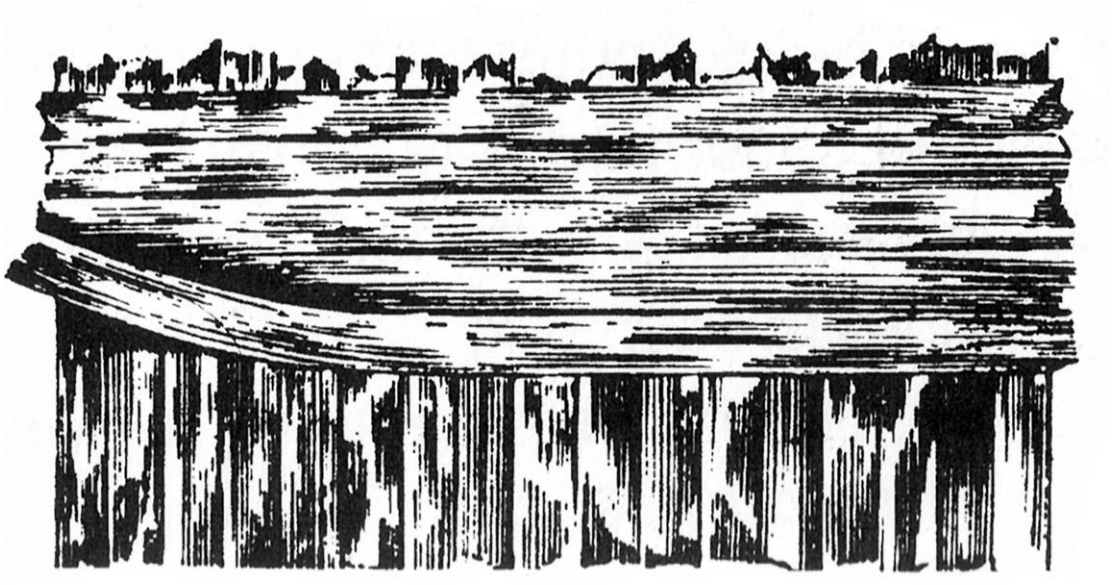


FIGURE 4-2 A DRAWING THAT ILLUSTRATES HOW A SHEET OF PAPYRUS IS FORMED[124]

Although papyrus is very similar to the paper, it is not paper in the true sense. It is only the first writing material that possesses many of the properties of the paper we

[121] Ann Heinrichs, 'The history of paper', in id., *The printing press* (New York: Franklin Watts, 2005), pp. 16-17.
[122] Nils J. Lindberg, 'Papyrus', in Hannu Paulapuro (ed.), *Papermaking Part 1, Stock preparation and wet end* (Helsinki: Fapet Oy; Atlanta, Georgia: TAPPI Press, 2000), p. 57.
[123] Shaaron Cosner, 'Papyrus', in id., *Paper through the ages* (Minneapolis, Minnesota: Carolrhoda Books, 1984), p. 22.
[124] Nils J. Lindberg, *op. cit.*

know today.[125] Credit for the invention of paper has been given to 'Ts'ai Lun' (or 'Cai Lun'), a eunuch who served at the imperial court during the reign of emperor 'Ho Ti' in the later first century C.E.[126] An ancient Chinese scholar once said "*Under the reign of Ho Ti (A.D. 89-105), Ts'ai Lun of Lei-yang, conceived the idea of making paper from the bark of trees, discarded cloth, and hemp well prepared; the paper was then in use in the entire universe.*"[127]

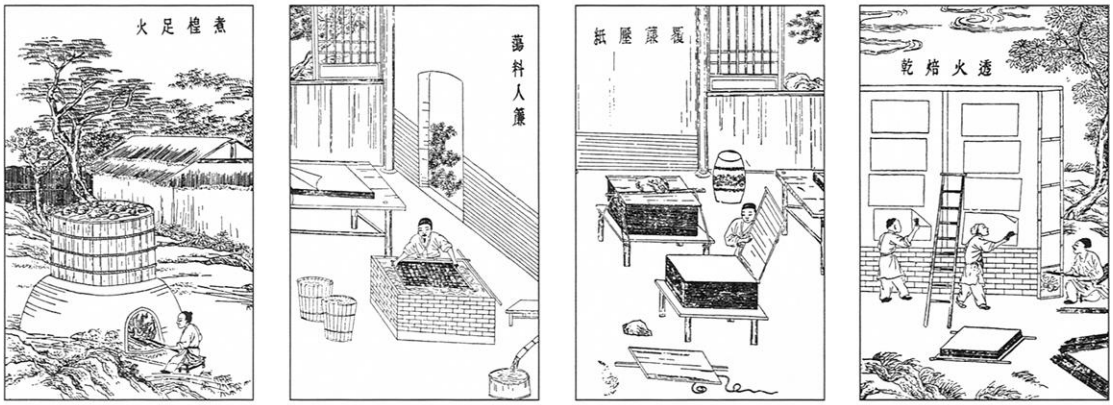


FIGURE 4-3 CHINESE PAINTINGS OF PAPERMAKING

The four main phases in papermaking: preparing the fiber, forming the sheet, pressing and drying.[128]

T'sai Lun conceived the idea of papermaking by mixing plant fibres extracted from the barks of mulberry-tree, hemp fibres, cloth rags and fishing nets,[129] and beaten into a mush called pulp.[130] The pulp is subsequently softened in water, and then

[125] Dard Hunter, 'Before paper: the writing substances of the ancients', in id., *Papermaking: the history and technique of an ancient craft* (2nd edn., New York: Dover Publications, 1978), p. 17.
[126] Jonathan M. Bloom, 'The invention of paper', in id., *Paper before print: the history and impact of paper in the Islamic world* (New Haven; London: Yale University Press, 2001), p. 32.
[127] Dard Hunter, 'Ts'ai Lun and the invention of paper: the influence of calligraphy upon paper and the influence of paper upon printing', in id., *Papermaking: the history and technique of an ancient craft* (2nd edn., New York: Dover Publications, 1978), p. 50.
[128] Josep Asunción, 'The invention of paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 14.
[129] *Ibid.*
[130] Shaaron Cosner, 'Paper', in id., *Paper through the ages* (Minneapolis, Minnesota: Carolrhoda Books, 1984), p. 33.

gathered on top of a woven fabric stretched across a wooden frame to form a sheet of paper.[131]

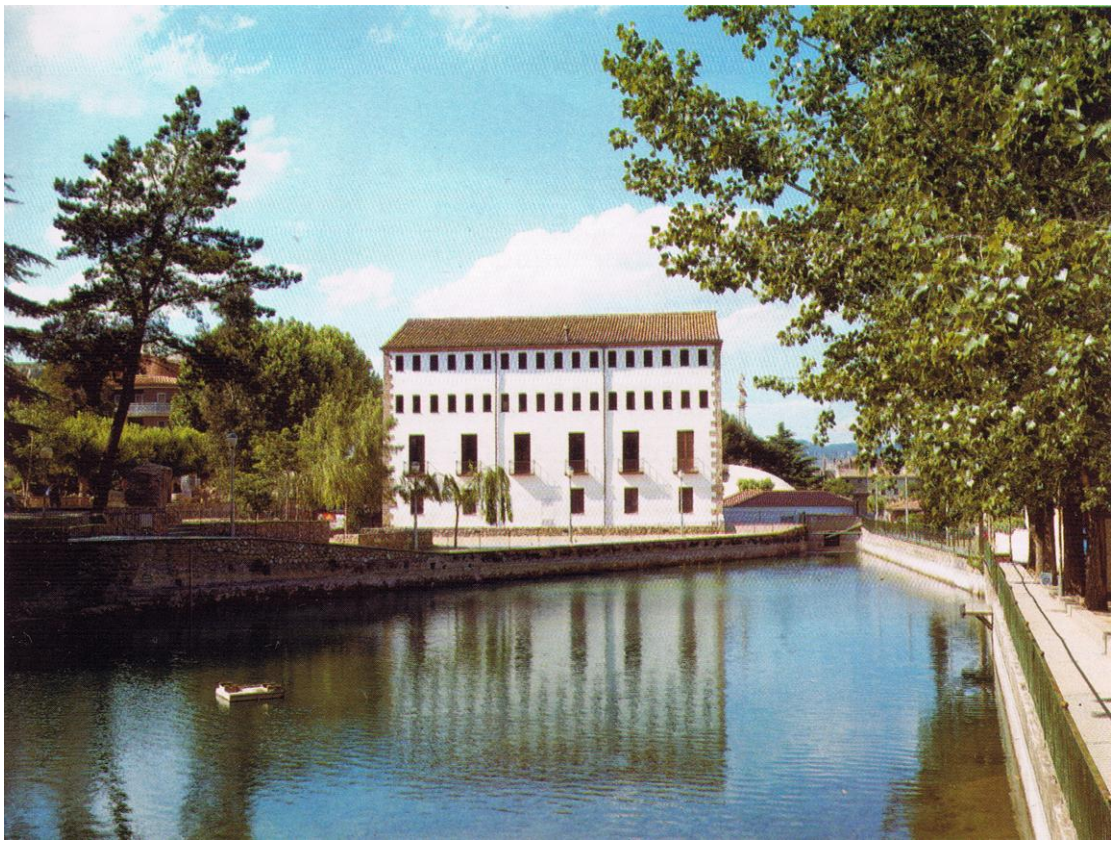


FIGURE 4-4 MOLI PAPERER DE CAPELLADES MUSEUM

This eighteenth-century mill in Cataluña, Spain, in which paper is still made by hand, is also among the most important European museums devoted to papermaking.[132]

IN A TRADITIONAL PAPER MILL

Even up until today many papers are still made by hand using the same method as it was invented in China over 2,000 years ago. The system of making paper by hand in a traditional paper mill involves four phases: first is to prepare the pulp, second is to

[131] Elizabeth Couzins-Scott, 'History of papermaking', id., *Papermaking: the craft of creative paperwork in 25 innovative projects* (London: Southwater, 2002) p. 8.

[132] Josep Asunción, 'A traditional paper mill', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 46.

form the sheet, third is the press, and forth is the finishing work, which involves the drying, smoothing and cutting of the sheets.[133]

FIGURE 4-5 PULP PREPARING

The stamper beaters are used for the preparation of the paper pulp in the traditional paper mill. There are three different types of stampers/hammers for the shredding, processing, or refining of raw materials.[134]

FIGURE 4-6 SHEET FORMING

The 'vat man', the worker with the greatest skill, is responsible for making the sheets in the vat using a mould.[135]

[133] Josep Asunción, 'Handmade paper and industrial paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 74.
[134] Josep Asunción, 'A traditional paper mill', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 48.
[135] *Ibid.*, p. 49.

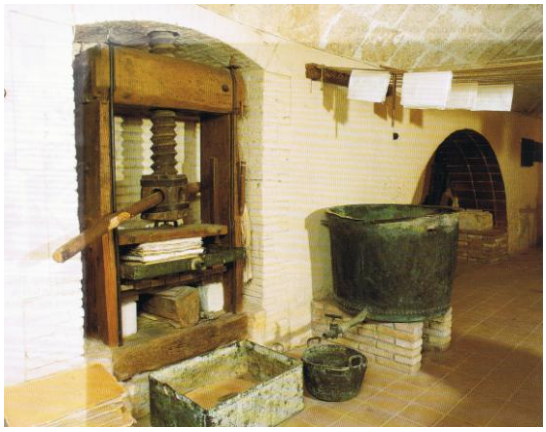


FIGURE 4-7 SHEET PRESSING

The press is indispensable in a paper mill. It is used to speed up the drying process of the sheets formed.[136]

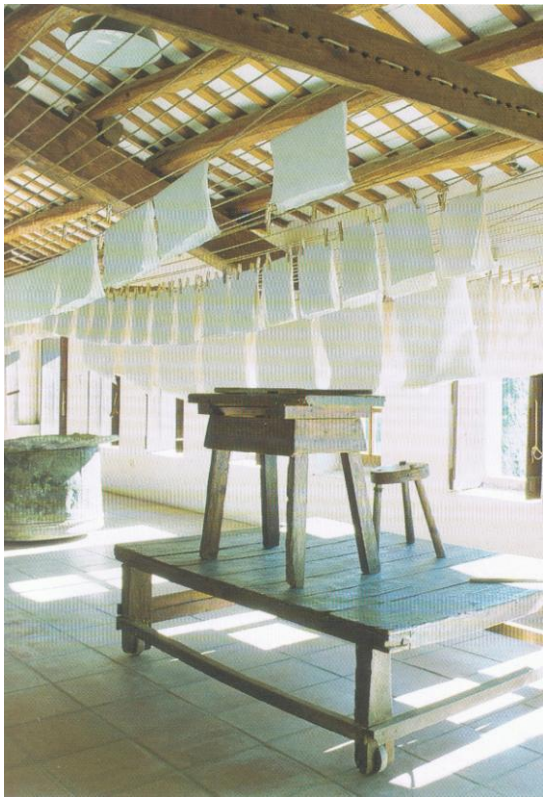


FIGURE 4-8 SHEET DRYING

The paper is hung up in the loft of the mill to dry naturally.[137]

[136] Josep Asunción, 'A traditional paper mill', in id., *The complete book of papermaking* (New York: Lark Books, 2003), pp. 49-50.
[137] *Ibid.*

THE SPREAD OF PAPER

The Chinese kept the secret of T'sai Lun's invention hidden from the Western World for over six hundred years,[138] until it was first introduced to the Arabs as a consequence of war during A.D. 751.[139] According to an old Arabic manuscript, two Chinese papermakers were taken among the other captives in the 'Battle of Talas', a conflict between the Arab and Chinese army in Samarkand, Central Asia[140], and they offered the knowledge of their craft in exchange for their freedom.[141]

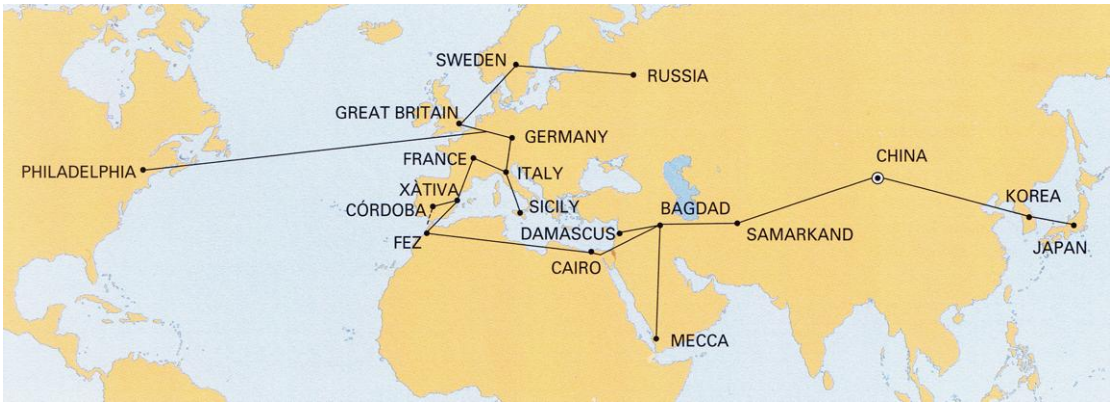


FIGURE 4-9 THE SPREAD OF PAPER[142]

It was not until a millennium had passed since the invention of paper by the Chinese, before the Europeans finally learned the art of papermaking.[143] In 1151 A.D., the Arabs took their knowledge of papermaking to Europe when they established the first

---

138 Elizabeth Couzins-Scott, 'History of papermaking', id., *Papermaking: the craft of creative paperwork in 25 innovative projects* (London: Southwater, 2002) p. 8.

139 Library of Congress, 'Arab countries and Europe', in id., *Papermaking: art and craft; an account derived from the exhibition presented in the Library of Congress, Washington, D.C., and opened on April 21, 1968* (Washington, D.C.: Library of Congress, 1968), p. 16.

140 Jonathan M. Bloom, 'The introduction of paper in the Islamic lands', in id., *Paper before print: the history and impact of paper in the Islamic world* (New Haven; London: Yale University Press, 2001), p. 42.

141 Library of Congress, *op. cit.*

142 Josep Asunción, 'The spread of paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 15.

143 Jonathan M. Bloom, 'Introduction', in id., *Paper before print: the history and impact of paper in the Islamic world* (New Haven; London: Yale University Press, 2001), p. 1.

paper-mill in Xativa, Spain.[144] The European paper industry started out from Spain and spread slowly through Europe during the fourteenth and fifteenth century.[145] However, it was not until the invention of printing by Johann Gutenberg in the 1450s that the great demand for paper began to take off.[146]

FIGURE 4-10 THE RENAISSANCE

During the Renaissance (around 1300 to 1600 A.D.), people craved to learn. The printing press allowed for new information to spread far and wide.[147]

RENAISSANCE AND THE DEMAND FOR BOOKS

Just before the Renaissance began, there had been a crisis in the demand for books. As the churches and monasteries in Europe increased in great numbers, the demand for copies of the Bible and other religious texts also grew dramatically as well.[148] At the same time, people were awakened to learning during the Renaissance. Sciences, such as medicine, chemistry and astronomy were flourishing. Explorers were also discovering new lands. People wanted to learn more about new scientific

144 Marna Elyea Kern, 'The history of papermaking', in id., *The complete book of handcrafted paper* (New York: Coward, McCann & Geoghegan, 1980), p. 17.
145 Sophie Dawson, 'The migration of paper' in id., *The art and craft of papermaking* (London: Quarto, 1992; repr. Asheville, North Carolina: Lark Books, 1996), p. 12.
146 Marna Elyea Kern, *op. cit.*
147 Ann Heinrichs, 'Rebirth and revolution', in id., *The printing press* (New York: Franklin Watts, 2005), p. 9.
148 Michael Pollard, 'Supply and demand', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 10-11.

ideas, as well as the history and information from faraway lands.[149] The escalating demand for books stirred the motivation to discover more efficient methods for producing books.[150]

FIGURE 4-11 WOODBLOCK PRINTING

Pages of a book printed from wooden blocks on which both text and illustrations had been craved.[151]

By the late 1300, woodblock printing had already taken place in Europe.[152] In woodblock printing, texts and images of a full-paged written material, such as

[149] Ann Heinrichs, 'Rebirth and revolution', in id., *The printing press* (New York: Franklin Watts, 2005), p. 9.

[150] Albert Kapr, 'The arts of writing and the book before Gutenberg', in id., *Johann Gutenberg: the man and his invention*, trans. Douglas Martin (3rd edn., Aldershot, Hants; Brookfield, Vermont: Scolar Press, 1996), p. 21.

[151] Michael Pollard, 'The first printers', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), p. 9.

posters, were hand-carved onto wooden blocks by skilled craftsmen. The blocks were subsequently covered with ink, and stamped onto paper to create copies of the written material. However, it is literally impractical to make copies of a book in this way, as every single page of the entire book would have to be hand-carved onto blocks of wood.[153]

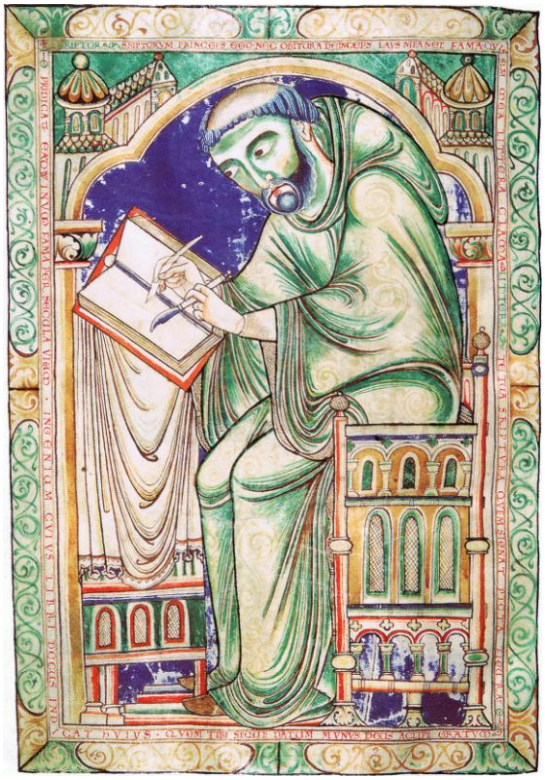


FIGURE 4-12 MONKS WORKED AS SCRIBES OR BOOK-COPIERS IN THE MONASTERIES

Eadwine, a Canterbury monk, drew this picture of himself working on a book of Psalm in about 1150.[154]

As a result, there were very few books produced in Europe up until the mid-fifteenth century,[155] and most of them were Christian scriptures and religious texts.[156] These works were mostly hand-written by monks who worked in the monasteries as scribes

---

[152] Lisa Mullins, 'Woodblocks in Europe', id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), p. 7.
[153] Gail B. Stewart, 'Johannes Gutenberg: developed a way to print', in id., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006), pp. 16-17.
[154] Richard Tames, 'Scribes and scripture', in id., *The printing press: a breakthrough in communication* (Oxford: Heinemann Library, 2000), p. 8.
[155] Gail B. Stewart, *op. cit.*
[156] Bradley Steffens, 'Books of the Middle Ages', in id., *Printing press: ideas into type* (San Diego, California: Lucent Book, 1990), pp. 21-22.

or book-copiers.[157] The production of books by writing is not only painstaking and time consuming; it is also peculiarly liable to inaccuracies.[158]

The production of books by writing was evidently incapable of meeting the rising demand of books. Printing with woodblocks was no more efficient as well.[159] A printing machine that could mass-produce books at a greater speed was an invention waiting to happen, and Johann Gutenberg's printing press changed it all.

FIGURE 4-13 JOHANN GUTENBERG[160]

JOHANN GUTENBERG AND HIS MOVABLE TYPE PRINTING PRESS

Johann (or Johannes) Gutenberg was born on June 24, 1398, in Mainz, Germany.[161] As a young boy, Gutenberg loves to watch how coins were made in the mint where

[157] Michael Pollard, 'A world without print', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 6-7.
[158] Victor Scholderer, 'Johann Gutenberg' in id., *Johann Gutenberg: the inventor of printing* (London: British Museum, 1970), p. 7.
[159] Ann Heinrichs, 'The master problem solver', in id., *The printing press* (New York: Franklin Watts, 2005), p. 10.
[160] Gail B. Stewart, 'Johannes Gutenberg: developed a way to print', in id., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006), p. 17.

his father worked. He was fascinated by how figures and letters were stamped on the coins by the coin-makers. Another of Gutenberg's interests was to watch the monks in the nearby monastery tediously copying pages after pages of the religious texts by hand.[162] Thus, it is believed that it is during those childhood days in Mainz when Gutenberg attained his first inkling of the idea that was to make his fame.[163]

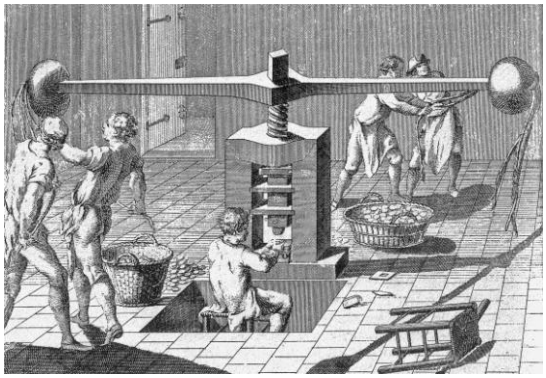


FIGURE 4-14 GUTENBERG'S IDEA

The screw press process in coin minting, which Gutenberg adopted the idea for his printing press.[164]

When Gutenberg moved to Strasbourg, Germany in 1428, and became a goldsmith himself,[165] he began to experiment with the idea of a printing press that used movable type.[166] Instead of creating a whole page from one block like woodblock printing, Gutenberg's idea was to make individual separate pieces of metal type for each alphabetic letter, numbers, punctuation marks and symbols.[167] These individual metal types can be put together to form a few pages of a book. When these pages

---

161 Albert Kapr, 'Gutenberg's origins, birth and parentage', in id., *Johann Gutenberg: the man and his invention*, trans. Douglas Martin (3rd edn., Aldershot, Hants; Brookfield, Vermont: Scolar Press, 1996), p. 29.

162 Douglas McTavish, 'Johann Gutenberg – Inventor of the printing press', in id., *Famous Inventors* (Hove, East Sussex: Wayland, 1993), pp. 4-6.

163 Michael Pollard, 'Comfortable beginnings', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 15-16.

164 Michael Pollard, 'The process of minting coins, which Gutenberg knew through his family and in which he may have trained, involved many of the techniques used to produce type. The impressions on the faces of coins were made by pressing hard metal dies on to "blanks" made of softer metal. In printing, the pieces of type were made in the same way', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), p. 20.

165 Douglas McTavish, *op. cit.*

166 Gail B. Stewart, 'Johannes Gutenberg: developed a way to print', in id., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006), pp. 16-17.

167 Ann Heinrichs, 'Movable type', in id., *The printing press* (New York: Franklin Watts, 2005), pp. 12-13.

had been printed, the metal types can be taken apart and rearranged into the next few pages of the book for print again.[168]

FIGURE 4-15 MOVABLE TYPE

Gutenberg's movable type printing press uses individual metal types like these to print a page of text.[169]

In 1448, Gutenberg returned to Mainz and established his own printing business. In 1453, he began printing his first book – a 1,282-page version of the Bible.[170] It used to take about four years to make a copy of the Bible by writing,[171] but with Gutenberg's printing press, 210 copies of the Bible were made within 5 years.[172]

[168] Michael Pollard, 'Movable type', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 12-13.
[169] Ann Heinrichs, 'Why not make the letter move', in id., *The printing press* (New York: Franklin Watts, 2005), p. 37.
[170] Douglas McTavish, 'Johann Gutenberg – Inventor of the printing press', in id., *Famous Inventors* (Hove, East Sussex: Wayland, 1993), pp. 4-6.
[171] Richard Tames, 'Print against pen', in id., *The printing press: a breakthrough in communication* (Oxford: Heinemann Library, 2000), p. 5.
[172] Gail B. Stewart, 'Johannes Gutenberg: developed a way to print', in id., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006), pp. 16-17.

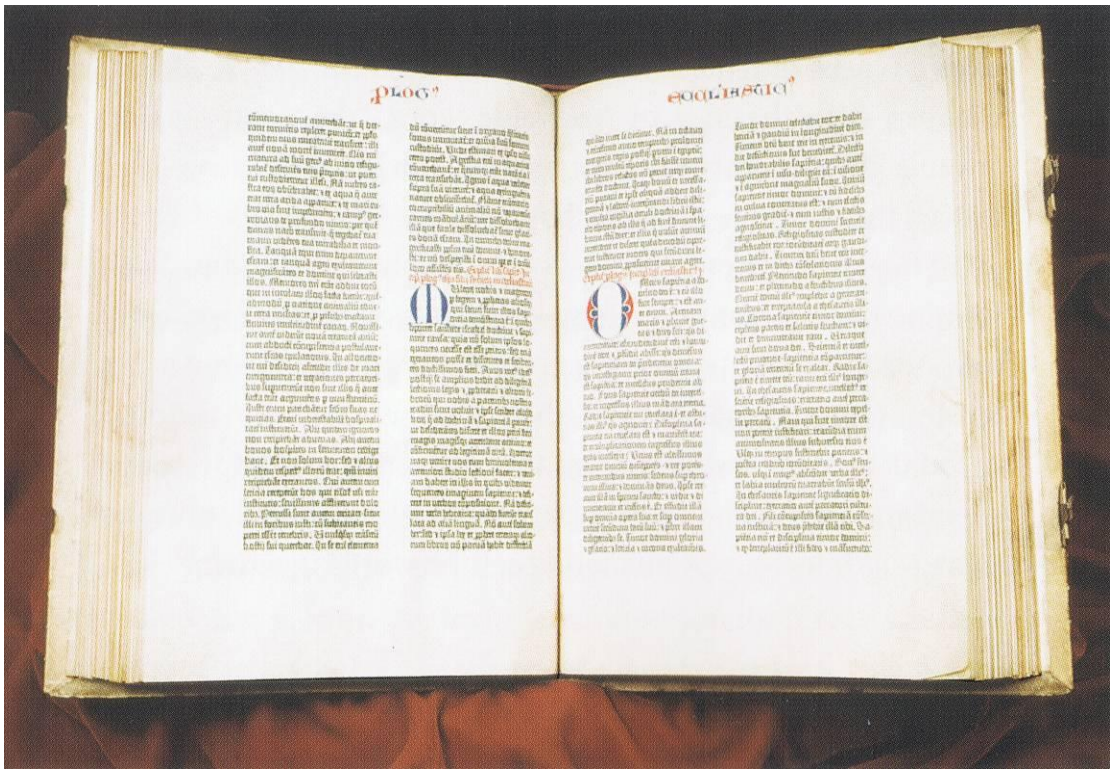


FIGURE 4-16 THE GUTENBERG'S BIBLE

The Gutenberg's Bible, the first book printed using movable type.[173]

Gutenberg's invention was a huge success. It seems as if the unmet demand for books pent-up over the years was finally freed by Gutenberg's invention.[174] The Gutenberg's art of printing spread swiftly. Within a few years, hundreds of printing shops throughout Europe were using Gutenberg's movable type printing press.[175]

[173] Samuel Willard Crompton, 'Early Printing: China, Japan, Korea, and Germany', id., *The printing press* (Philadelphia, Pennsylvania: Chelsea House Publishers, 2004), p. 20.

[174] Michael Pollard, 'The age of print', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 36-38.

[175] Gail B. Stewart, 'Johannes Gutenberg: developed a way to print', in id., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006), pp. 16-17.

FIGURE 4-17 A DRAWING OF A PRINTING SHOP IN GERMANY IN THE 1500S[176]

AFTER THE INVENTION OF GUTENBERG'S PRINTING PRESS

Before Gutenberg's invention, only about twenty to thirty thousand books existed in Europe.[177] By 1500, less than fifty years after Gutenberg's invention, the number had risen to more than nine million books in print.[178] Furthermore, when Gutenberg's Bible was printed, there were probably only a few thousand people in Europe who could read, of which most of them were monks and priests.[179] However, Gutenberg's printing press changed all that. It took the learning and knowledge that was formerly

[176] Richard Tames, 'A print shop in Germany in 1500s', in id., *The printing press: a breakthrough in communication* (Oxford: Heinemann Library, 2000), p. 11.
[177] Lisa Mullins, 'Working with books', id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), p. 15.
[178] Ann Heinrichs, 'The information explosion', in id., *The printing press* (New York: Franklin Watts, 2005), pp. 47-48.
[179] Michael Pollard, 'Reading explosion!', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 57-60.

only for a privileged few, and shared with everyone else.[180] With the spread of education in the nineteenth century, reading became popular.[181]

From the 1450s to 1800, only minor changes were made to Guteberg's printing press. Minor changes such as replacing the wooden screw press with iron ones to add extended strength and durability to the printing press. More significant improvements were made between 1800 and 1960 that really sped up the printing process and made the printers' jobs easier.[182] For example, in 1811, German printer Friedrich Koenig and his associate, Andreas Bauer built the first printing press powered by steam engine, and their invention was installed at 'Times', London's daily newspaper publisher. With the steam press, Times were able to produce 1,100 copies of newspapers per hour, and it was proudly announced that the invention was "*the greatest improvement connected with printing since the discovery of the art itself.*"[183] Later in 1818, Koenig and Bauer also designed a double press that created the first double-sided printing.[184] The inventions by Koenig and Bauer saved enormous amount of time and money for the publishers.[185]

In 1904, America printer, Ira W. Rubel discovered a new printing technique known as offset printing. In offset printing, the inked image on the printing plate is printed on a rubber cylinder and then transferred onto the paper. This gives printing a great flexibility, as the rubber cylinder permits printing on wood, cloth, metal, leather and

---

[180] Stephen Krensky, 'The printing press took learning and knowledge from just a privileged few and shared them with everyone else. And that change, more than any other act, set the stage for the modern world to come.', in id., *Breaking into print: before and after the invention of the printing press* (Boston: Little, Brown & Co., 1996), p. 29.

[181] Michael Pollard, 'Opportunity', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), p. 60.

[182] Lisa Mullins, 'More words', id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), p. 16.

[183] Michael Pollard, 'Steam', in id., *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992), pp. 49-50.

[184] Encyclopedia Britannica, Inc., 'Printing (publishing)', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/477017/printing>, accessed 16 Apr. 2008.

[185] Lisa Mullins, *op. cit.*

rough paper.[186] This printing technique is still widely used even up till today, especially in newspaper publishing. Subsequently, the printing presses also moved from steam-powered to electric-powered during the 1920s.[187]

THE TYPEWRITER AND THE PHOTOCOPYING MACHINE

"*Along with the printing press, the typewriter represents an important level of automation for the printing industry. While the printing press is designed for the mass production of literature, the typewriter is more of a personal instrument*," say Dr. Michael Windelspech in his book, 'Groundbreaking scientific experiments, inventions, and discoveries of the 19th century'.[188]

The invention of the first typewriter is credited to a former Milwaukee newspaper editor named Christopher Latham Sholes.[189] Before Sholes' invention, there were in fact several attempts to invent an automated system of writing, but none of them met with much success. Sholes who had some prior experience with the development of a page-numbering machine and was trained as an editor and printer, managed to develop the first successful typewriter together with two of his friends, Samuel W. Soule and Carlos Glidden, in 1868.[190] The trio filed a patent for their invention in the following year, and in 1873, they sold the patent rights to James Densmore and George W. Yost, who in turn arranged for production of the machine by E.

---

[186] Encyclopedia Britannica, Inc., 'Offset printing', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/425722/offset-printing>, accessed 18 Apr. 2008.
[187] Lisa Mullins, 'Parts of a press', id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), p. 20.
[188] Michael Windelspecht, 'Typewriter', in id., *Groundbreaking scientific experiments, inventions, and discoveries of the 19th century* (Westport, Connecticut: Greenwood Press, 2003), p. 232.
[189] James M. Utterback, 'The dynamics of innovation in industry', in id., *Mastering the dynamics of innovation: how companies can seize opportunities in the face of technological change* (Boston, Massachusetts: Harvard Business School Press, 1994), p. 2.
[190] Michael Windelspecht, *op. cit.*

Remington Sons, a renowned maker of arms and sewing machines.[191] In 1874, the Remington typewriters were on the market.[192]

FIGURE 4-18 THE EARLY TYPEWRITERS[193]

Just months after the Remington typewriters went on sale, American writer Mark Twain got for himself one of these new writing tools and became the first writer to submit a fully typewritten book manuscript to the publisher.[194] Kendall Haven, a research scientist and award-winning author, also describes in his book that, "*Typewriters revolutionized office structure and office procedure, and created a social revolution as well. By 1895, business executives considered the typewriter to be so important that they created a new kind of office position – typist. Most of the people hired for typing jobs were women. For the first time in history, large masses of women marched out of the house alongside their husbands each morning to go out to work. It represented a social revolution. Over 100,000 American women worked as typists by 1898 – a position that hadn't existed a few years before. In June 1892 Education Magazine called typewriters, 'a necessity of modern civilization.' By 1910,*

[191] Vaclav Smil, 'Printed Word', in id., *Creating the Twentieth Century* (Oxford; New York: Oxford University Press, 2005), p. 207.
[192] Naomi S. Baron, 'The typewriter revolution', in id., *Alphabet to email: how written English evolved and where it's heading* (London; New York: Routledge, 2000), p. 200.
[193] Early Office Museum, 'Typewriters', *Early Office Museum* [website], <http://www.officemuseum.com/typewriters.htm>, accessed 21 Apr. 2008.
[194] Naomi S. Baron, *op. cit.*, p. 202.

typewritten material was the one universally accepted form of business and government communication."[195]

FIGURE 4-19 HALOID XEROX 914 OFFICE COPIER

The first automatic office copier that makes copies on plain paper was introduced in 1959.[196]

In 1959, a small photographic supply company, named the Haloid Company, in Rochester, New York introduced the world's first plain-paper office copier using a revolutionarily new process called 'xerography'. This copying process was invented by a Seattle-born patent attorney named Chester Carlson.[197] "*Xerography is a taking system with amplification, based on a reusable photoconductor as the photosensitive receptor and a plain paper hard copy. The photoconductor, in the form of a rotating belt or drum, is corona charged, then imaged with light in a scanning mode (because of the short lifetime of the charge) to create a negative discharge image. The positive charge image is treated with dry toner powder (carbon borne by a carrier) or with fast-drying liquid toner suspensions in later devices, leaving a positive image in tone on the photoconductor. The toner image is transferred on plain paper by a charging*

[195] Kendall F. Haven, 'Typewriter', in id., *100 greatest science inventions of all time* (Westport, Connecticut: Libraries Unlimited, 2006), p. 141.

[196] Industrial Designers Society of America, 'Xerox 914 Copier: 1959', *Industrial Designers Society of America* [website], <http://new.idsa.org/webmodules/articles/anmviewer.asp?a=272&z=62>, accessed 21 Apr. 2008.

[197] David Owen, 'Copies in seconds', in id. *Copies in seconds: how a lone inventor and an unknown company created the biggest communications breakthrough since Gutenberg: Chester Carlson and the birth of the Xerox machine* (New York: Simon & Schuster, 2004), pp. 10-12.

sequence and is thermally fused to the paper to make the final image."[198] This first office copier, known as the Haloid Xerox 914 Office Copier, was able to make sharp and permanent copies on ordinary paper at a rate that was faster than any other machines made by other companies.[199] The Haloid Xerox 914 Office Copier very quickly became a hot-selling product,[200] and helped its manufacturer grew from a small obscure company with revenues of $33 million in 1959 to a major corporation, the Rank Xerox Corporation, with revenues of $176 million by 1963 and $4 billion by 1975.[201] Up until today, Carlson's invention still remains the cornerstone of the worldwide copying industry, producing billions and billions of copies a year.[202] Like the invention of the printing press has evidently escalated the use of paper through the rapid production of books, the invention of the typewriter and photocopier has also increased paper consumption through the rapid duplication of paper documents.

GOING DIGITAL AND PAPERLESS

However, the greatest impact to the printing press was brought by the invention of electronic desktop computer in the 1960s. The computer allows people to compose all the texts and designs on a computer screen before sending them to a digital printer for print.[203] Samuel Willard Crompton in his book, 'The printing press', writes that the personal computer has made every man his own printer. He described that

---

198 Allan Shepp, 'Introduction to images and imaging', in Allan Shepp, John M. Sturge and Vivian Walworth (eds.), *Imaging processes and materials* (8th edn., New York : Van Nostrand Reinhold, 1989), p. 7.

199 David Owen, 'Copies in seconds', in id. *Copies in seconds: how a lone inventor and an unknown company created the biggest communications breakthrough since Gutenberg: Chester Carlson and the birth of the Xerox machine* (New York: Simon & Schuster, 2004), pp. 10-12.

200 Dane R. Gordon, 'The Chester Carlson Building', in id., *Rochester Institute of Technology: Industrial Development and Educational Innovation in an American City, 1829-2006* (Rochester, New York: Cary Graphic Arts Press, 2007), p. 413.

201 Mohamed Zairi, 'Rank Xerox: the benchmark of benchmarking', in id., *Effective benchmarking: learning from the best* (London: Chapman & Hall, 1996), p. 11.

202 The Great Idea Finder, 'Xerography history – Invention of xerography', *The Great Idea Finder* [website], updated Feb. 2005, <http://www.ideafinder.com/history/inventions/xerography.htm>, accessed 23 Apr. 2008.

203 Lisa Mullins, 'Using computers', in id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), pp. 24-25.

the printing press today has taken "*the form of the personal computer and printer in the offices and homes*".[204]

FIGURE 4-20 DESKTOP PUBLISHING

A field where publishing professionals use computer programs to design and create a variety of printed or online materials.[205]

The computer networks and the Internet subsequently ushered in the Information Age.[206] The Internet is made up of a vast network of individual computers hooked up together to one another and act as file servers to store huge amount of data.[207] Today, the Internet allows people to publish information and written works in cyberspace to millions of readers, without having the need to go into print. Imagine how surprised Gutenberg would have been to discover that a book could now be published online for people to read off a computer screen instead of on printed page.[208] Some claim that the computer networks and the Internet are the greatest advancement in human communication since Gutenberg invented printing.[209]

---

[204] Samuel Willard Crompton, 'Every man his own printer: The personal computer', in id., *The printing press* (Philadelphia, Pennsylvania: Chelsea House, 2004), p. 94.
[205] Allison J. Ross, 'Books and manuals are designed and typeset by desktop publishing professionals', in id., *Careers in desktop publishing* (New York: Rosen Publishing, 2000), p. 44.
[206] Ann Heinrichs, 'Hot type goes cold', in id., *The printing press* (New York: Franklin Watts, 2005), pp. 63-65.
[207] Gareth Ward, 'The Internet and Intranets', in id., *Publishing in the digital age* (London: Bowerdean, 1998), p. 19.
[208] Ann Heinrichs, 'Books in the Information Age', in id., *The printing press* (New York: Franklin Watts, 2005), p. 65.
[209] Christine L. Borgman, 'Preface', in id., *From Gutenberg to the global information infrastructure: access to information in the network world* (Cambridge, Massachusetts: MIT Press, 2000), p. ix.

The dawn of the Information Age inspired many predictions. Some said that printed books would be obsolete one day.[210] Frank Koelsch in his book, 'The Infomedia Revolution: How it is changing our world and your life', describes that, "*In some ways, paper-based information is convenient. In others it is worse than unmanageable. A single book, magazine or newspaper is convenient. It's easy to carry about and handy to use. Many books and magazines rapidly become unwieldy. For the ardent reader, moving to a new house means lugging boxes of books, magazines and sundry reading material. Finding a place to store them is equally frustrating and time-consuming.*"[211] With audio-books - books read aloud by authors or actors that can be downloaded from the Internet to desktop computers, or portable laptops and handheld computers, and the formerly huge and heavy paper-based dictionaries and encyclopaedias that now can be stored and sold in a single compact disk, it is little wonder that some people would question if printing presses will one day be no longer necessary.[212]

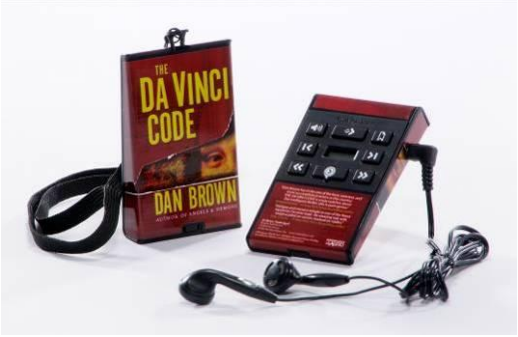


FIGURE 4-21 DIGITAL AUDIO BOOK

The 'Playaway' – a newest form of pocketsize digital audio book that comes preloaded with one book for users to listen to on the go.[213]

[210] Ann Heinrichs, 'Books in the Information Age', in id., *The printing press* (New York: Franklin Watts, 2005), p. 65.
[211] Frank Koelsch, 'Paperless publishing', in id., *The infomedia revolution: how it is changing our world and your life* (Toronto: McGraw-Hill Ryerson, 1995), p. 257.
[212] Lisa Mullins, 'No need for printing press', in id., *Inventing the printing press* (New York: Crabtree Publishing, 2007), p. 31.
[213] Findaway World, 'What is Playaway', *Playaway* [website], updated 01 Aug. 2006, <http://store.playawaydigital.com/How-to-Play/Getting-Started>, accessed 25 Apr. 2008.

The expectation that the development of electronic technologies would make paper a thing of the past is also the basis for the concept of a 'paperless office'.[214] The development of the computer networks and the Internet in the 1970s had unquestionably changed office life, and has led many to think that paper would at last disappear because documents can now be circulated digitally without the need for a physical paper printout.[215]

The environmentalists are certainly supportive towards the ideal of a 'paperless office' and even more of a 'paperless society'. Many believe that the massive use of paper in the production of books, magazines, newspapers and other such products is destroying our forests today.[216]

A PAPERLESS SOCIETY REMAINS ONLY A MYTH

Despite all of the grand claims that the computers and the Internet would bring about a 'paperless office' and even a 'paperless society' since the 1970s, one truth however seems to have dashed all such claims: our paper consumption had kept rising. Contrary to the belief that the computers and the Internet would decrease paper consumption, they in actual fact escalated the amount of printing done in homes and offices.[217] Mark Y. Herring in his book, 'Fool's gold: why the Internet is no substitute for a library', noted this: "*Not only has the paperless anything not found us, we are awash in paper more than ever before.*"[218]

---

[214] Abigail J. Sellen and Richard H. R. Harper, 'Origin of the myth of the paperless office', in id., *The myth of the paperless office* (Cambridge, Massachusetts: MIT Press, 2002), p. 2.
[215] *Ibid.*, pp. 5-8.
[216] Frank Koelsch, 'Save a tree', in id., *The infomedia revolution: how it is changing our world and your life* (Toronto: McGraw-Hill Ryerson, 1995), p. 270.
[217] Abigail J. Sellen and Richard H. R. Harper, *op. cit.*
[218] Mark Y. Herring, 'Paperless society perfect for the age of illiteracy', in id., *Fool's gold: why the Internet is no substitute for a library* (Jefferson, North Carolina: McFarland & Company, 2007), pp. 120-121.

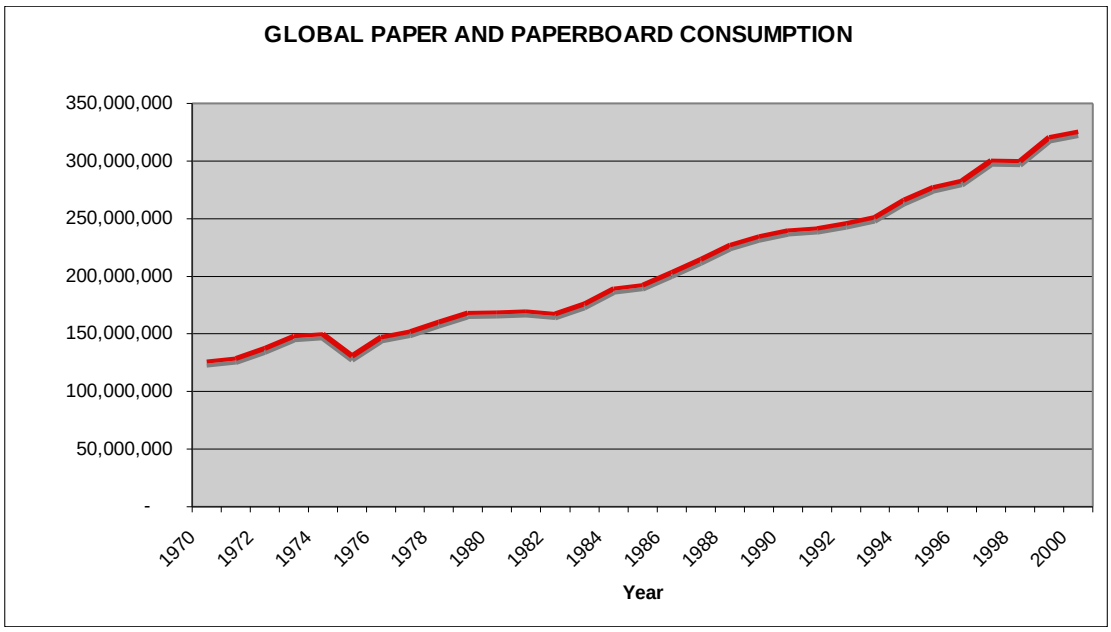


FIGURE 4-22 GLOBAL PAPER AND PAPERBOARD CONSUMPTION ANNUALLY FROM 1970-2000[219]

The World Resources Institute reported that the global paper consumption has increased about twenty times in this century, and has more than tripled over the past thirty years.[220] It was commented that, "*By one estimate, personal computers in the early 1990s accounted for 115 billion sheets of paper per year worldwide; today Hewlett-Packard estimates that laser printers in North America alone are churning out 1.2 trillion pages annually. Offices continue to rely on paper for files and records; just 10 percent of office documentation was in digital form as of the mid-1990.*"[221]

Far from attaining a 'paperless' society, the paper usage globally has evidently not decreased, but has increased enormously. In fact, the Food and Agriculture Organization (FAO) of the United Nation has projected that paper consumption

[219] World Resources Institute, 'Resource consumption: paper and paperboard consumption', *EarthTrends Energy and Resource* [online database], updated Dec. 2006, <http://earthtrends.wri.org/searchable_db/index.php?theme=6>, accessed 30 Apr. 2008.
[220] Wendy Vanasselt (ed.), 'No end to paperwork', *World Resource 1998-99*, <http://earthtrends.wri.org/pdf_library/feature/ene_fea_paper.pdf>, accessed 30 Apr. 2008.
[221] *Ibid.*

worldwide will grow by another fifty percent from 2000 to 2010.[222] Perhaps just like what Herring described in his book, "*Almost no one talks about the paperless society now that we know we cannot get along without paper.*"[223] Herring also noted this, "*A paperless society cannot be the goal of a culture that values knowledge and still distinguishes (however more dimly) between knowledge and information.*"[224]

THE PREFERENCE FOR PAPER

Many believe that one of the greatest obstacles in realizing a paperless future lays on our preference of reading from papers instead of from screens.[225] So much so that even with all of the advancement in electronic reading technologies at hand, reading is still believed to be best accomplished on paper.[226] Abigail J. Sellen and Richard H. R. Harper in their investigation found four main reasons why paper supports reading so successfully:

1. Paper helps us flexibly navigate through documents.
2. Paper facilitates the cross-referencing of more than one document at a time.
3. Paper allows us to annotate documents easily
4. Paper allows the interweaving of reading and writing.[227]

Abigail J. Sellen and Richard H. R. Harper in their book, 'The Myth of the Paperless Office', said that, "*It is perhaps no surprise, then, that the technologies that have been developed to support reading to date have not been as successful as*

---

[222] Wendy Vanasselt (ed.), 'No end to paperwork', *World Resource 1998-99*, <http://earthtrends.wri.org/pdf_library/feature/ene_fea_paper.pdf>, accessed 30 Apr. 2008.

[223] Mark Y. Herring, 'Random date, not information', in id., *Fool's gold: why the Internet is no substitute for a library* (Jefferson, North Carolina: McFarland & Company, 2007), pp. 120-121.

[224] *Ibid.*

[225] Abigail J. Sellen and Richard H. R. Harper, 'Reading from paper', in id., *The myth of the paperless office* (Cambridge, Massachusetts: MIT Press, 2002), p. 75.

[226] Mark Y. Herring, 'Paperless society perfect for the age of illiteracy', in id., *Fool's gold: why the Internet is no substitute for a library* (Jefferson, North Carolina: McFarland & Company, 2007), pp. 121-122.

[227] Abigail J. Sellen and Richard H. R. Harper, 'The affordances of paper for reading', in id., *The myth of the paperless office* (Cambridge, Massachusetts: MIT Press, 2002), p. 76.

predicted."[228] And along the same line, Herring also describes in his book that, "*Reading requires time, effort, and great mental agility, something that does not lend itself well to the flickering of so many computer screens.*"[229]. He also added that, "*Typical computer screens, even the best one, put out words at resolutions of far less magnitude than even the poorest paper in books.*"[230]

If we proceed along these lines, it would become evidential that the coming of a paperless society is highly unlikely, at least not within the near future. So we now stand in this dilemma between our preference towards paper, especially in reading and writing, and the rising issue of paper consumption worldwide escalating, which the environmentalists believe is destroying our forests. The question now is how we could manage these two matters at the same time, as they seem to be very much intertwined with each other.

[228] Abigail J. Sellen and Richard H. R. Harper, 'The affordances of paper for reading', in id., *The myth of the paperless office* (Cambridge, Massachusetts: MIT Press, 2002), p. 76.
[229] Mark Y. Herring, 'Paperless society perfect for the age of illiteracy', in id., *Fool's gold: why the Internet is no substitute for a library* (Jefferson, North Carolina: McFarland & Company, 2007), pp. 121-122.
[230] *Ibid.*

FIGURE 4-23 A PAPER RECYCLING CENTER

In a paper recycling center, paper is shredded into pieces and hot water is added to make a pulp. The pulp is cleaned, squashed, dried and pressed to make new sheets of paper.[231]

RECYCLED PAPER AND PAPER RECYCLING

The first record of paper recycling was in Japan during 1031 A.D. However, it was not until the First World War that the use of recovered paper reached a significant quantity.[232] At the start of World War I, a drop in import occurred in the United States (U.S.), which resulted in a shortage of fiber for the production of paper. By 1916, The U.S. Department of Commerce began to advertise extensively on behalf of paper mills to encourage the public to save old rags as well as old paper. For the first time, used paper became a valuable commodity, and for thousands of tons of old books, newspapers, and business papers were being recycling in the U.S. paper mills.[233]

---

[231] Sue Baaraclough, 'Recycling glass and paper', in id., *The recycling centre* (London: Franklin Watts, 2006), p. 25.

[232] Tom Friberg, Lisa Max and Lynn M. Thompson, 'Paper', in Herbert F. Lund (ed.), *The McGraw-Hill recycling handbook* (2nd edn., New York: McGraw-Hill, 2001), p. 11.1

[233] Claudia G. Thompson, 'A brief history of papermaking', in id., *Recycled papers: the essential guide* (Cambridge, Massachusetts: MIT Press, 1992), p. 33.

FIGURE 4-24 A TYPICAL PAPER RECYCLING PROCESS[234]

Recycled paper is made by re-pulping a variety of high-grade wastepaper to reclaim only the cellulose fiber and then using this old fiber in the manufacture of new paper.[235] In general, paper is recycled through a five-stage process:

- **Stage 1:** Used paper is collected from the recycling bins.
- **Stage 2:** Different types of paper are separated into pure streams.
- **Stage 3:** Paper is shredded and mixed with water to make paper pulp. Chemicals are added to the paper pulp to remove ink and glue.
- **Stage 4:** Recycled paper pulp is added to new paper pulp.
- **Stage 5:** Paper pulp is made into new paper products.[236]

Used paper products can be recycled into the same products again, or made into other paper products. However, paper can only be recycled in an open-loop recycling, which means paper cannot be recycled in a continuous closed-loop like steel, aluminium or glass into new products again and again, and never be wasted. The fibers of paper become weaker and shorter each time it is reprocessed. After being recycled several times, the weakened paper fibers get washed away in the de-

[234] Kate Walker, 'How paper is recycled', in id., *Paper* (South Yarra, Victoria: Macmillan Education Australia, 2009), pp. 12-13.
[235] Claudia G. Thompson, 'How recycled papers are made', in id., *Recycled papers: the essential guide* (Cambridge, Massachusetts: MIT Press, 1992), p. 37.
[236] Kate Walker, *op. cit.*

inking process. All grades of paper can only be reprocessed about seven times, and after that, they are thrown away.[237]

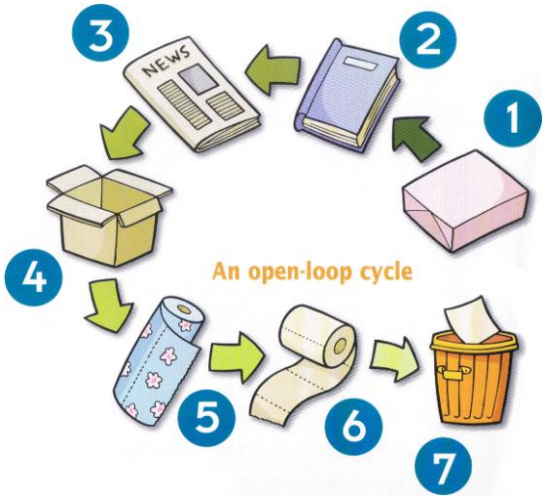


FIGURE 4-25 OPEN-LOOP RECYCLING

All paper is recycled in an open loop.[238]

It is also important to note that not all paper can be recycled as well. Paper coated with wax or plastic is non-recyclable, as it is too costly and uneconomical to remove wax and plastic from paper. Paper contaminated with food or oil is also non-recyclable, as food and oil often cause problem in the paper-pulping process.

[237] Kate Walker, 'Recycled paper product', in id., *Recycle, reduce, reuse, rethink* (South Yarra, Victoria: Macmillan Education, 2007), p. 94.
[238] *Ibid.*

TABLE 4-1 RECYCLABLE AND NON-RECYCLABLE PAPER[239]

Recyclable paper	Non-recyclable paper
Office paper	Plastic laminated paper
Newspapers	Waxed paper
Telephone directories	Pizza boxes
Envelopes	Juice boxes
Greeting cards	Coffee cups
Cardboard	Blueprints/carbon paper
Tissue boxes	Tissue/toilet paper
Egg cartons	Milk cartons

Although office paper is categorized under recyclable paper, it is said that contrary to common assumption, almost none of the office paper collected in the United States, if it contains photocopied or laser-printed materials, is recycled into new printing and writing paper.[240] It is also said that the recycling of newspaper creates more water pollution than making new paper. When old newspaper is recycled, every hundred tons of de-inked fiber will produce forty tons of toxic sludge that requires special disposal.[241] So is paper recycling truly environment friendly?

OPPOSING VIEWPOINTS TO PAPER RECYCLING

Economist Asa Janney in his writing, 'Curbside Recyling Wastes Environmental and Economic Resources', states that: *"The claim that recycling always protects the environment is another myth. Again, you have to look at the big picture. Recycling is not just stacking your newspapers at the curb; it also involves a manufacturing process which has environmental consequences. The EPA [Environmental Protection Agency] says that twelve toxic substances are found in both virgin and*

[239] Think Green, 'Recycling paper', in id., *Recycling* (Irvine, California: Saddleback Education Publishing, 2009), p. 18.
[240] Claudia G. Thompson, 'How recycled papers are made', in id., *Recycled papers: the essential guide* (Cambridge, Massachusetts: MIT Press, 1992), p. 37.
[241] Asa Janney, 'Curbside recycling wastes environmental and economic resource', in Mitchell Young (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 97.

recycled paper processing. Eleven of these are present at higher levels in the recycling process."[242] Professor Daniel Benjamin of Clemson University also agrees that it is myth that recycling always protects the environment. In his writing, 'The Eight Myths of Recycling', Professor Benjamin describes that, "*Recycling is a manufacturing process, and therefore it too has environment impact. The U.S. Office of Technology Assessment says it is not clear whether secondary manufacturing [i.e. recycling] produces less pollution per ton of material processed than primary manufacturing. Recycling merely changes the nature of pollution – sometimes decreasing it, and sometimes increasing it.*"[243]

Professor Benjamin adds that, "*To address the issue of paper, the most-promoted form of recycling: The amount of new growth that occurs each year in forests is more than 20 times the number of trees consumed by the world each year for wood and paper. Where loss of forest land is taking place, as in tropical rain forests, it can be traced directly to a lack of private property rights. Governments have used forests, especially the valuable tropical ones, as an easy way to raise quick cash. Wherever private property rights to forests are well-defined and enforced, forests are either stable or growing. More recycling of paper or cardboard would not eliminate tropical forest losses."* Professor Roy E. Cordato of Campbell University also states that, "*If we stopped using paper, there would be fewer trees planted. In the paper industry, 87% of the trees used are planted to produce paper. For every 13 trees 'saved' by recycling, 87 will never get planted. It is because of the demand for paper that the number of trees has been increasing in this country [i.e. the United States] for the*

[242] Asa Janney, 'Curbside recycling wastes environmental and economic resource', in Mitchell Young (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 96.
[243] Daniel Benjamin, 'Recycling is not environmentally friendly', in Lauri S. Friedman (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 74.

last fifty years. The lesson is this: if your goal is to maximize the number of trees, don't recycle."[244]

Danish professor and author of 'The Skeptical Environmentalist' Bjørn Lomorg agrees that there is no need to worry about wood and paper as they are both renewable resources.[245] Jerry Taylor of Cato Institute describes this: "*Paper is an agricultural product, made from trees grown specifically for paper production. Acting to conserve trees by recycling paper is like acting to conserve cornstalks by cutting back on corn consumption."*[246] And Asa Janney, in his writing, concluded that, "*Recycling may be the most wasteful activity in modern America: a waste of time and money, a waste of human and natural resources.*"[247]

'Green design' advocate Adam Beazley, however, has an opposing viewpoint to this. Beazley started this writing, 'Recycling Is Better for the Environment' with this: "*Is recycling better for the environment or not?... Yes, yes and absolutely yes! I am not sure where people are getting these ideas that recycling is worse for the environment, but nothing could be further from the truth.*"[248] He then presented some evidences to support his claim, "*When talking about recycling any type of material, a key term that will always show that recycling is better is source reduction. Source reduction is a direct result of recycling and affects the entire life cycle of the product. As it relates to paper, when you reduce the use of new paper, you are also reducing the negative environmental effects of producing that new paper...When a forest is cut down to produce paper, not only is pollution produced from the use of diesel*

[244] Asa Janney, 'Curbside recycling wastes environmental and economic resource', in Mitchell Young (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 97.
[245] Bjørn Lomorg, 'The United States has room for twenty-first-century garbage', in Mitchell Young (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 34.
[246] Asa Janney, *op. cit.*
[247] *Ibid.*, p.96.
[248] Adam Beazely, 'Recycling is better for the environment', in Viqi Wagner (ed.), *Recycling* (Farmington Hills, Michigan: Greenhaven Press, 2009), p. 31.

machinery, but when the wood is turned to pulp, it releases all of the CO_2 [i.e. carbon dioxide] that it has spent its entire life storing. Although trees are considered carbon neutral because they only releasing carbon that they have absorbed, the CO_2 released from the erosion of the topsoil is not carbon neutral because that topsoil loss would not have happened otherwise."[249]

TABLE 4-2 THE BENEFITS OF RECYCLED PAPER PRODUCTION OVER NEW PAPER PRODUCTION[250]

Virgin Paper	Recycled paper
Clear Cutting - Loss of natural resources (trees) - Erosion of topsoil - Use of diesel machinery to cut and transport raw materials	**No Clear Cutting**
Paper Mill - Wood releases stored CO_2 - Energy to process trees into pulp	**Paper Mill** - No new releases of stored CO_2 - Less energy to process paper into pulp
Consumerism - Paper shipped to stores - Paper bought, used, and discarded	**Consumerism** - Paper shipped to stores - Paper bought, used, and discarded
Paper to Landfill - Paper is brought to landfill - Paper biodegrades, producing methane	**Paper Recycled** - Paper is picked up by diesel trucks and brought to paper mill

[249] Adam Beazely, 'Recycling is better for the environment', in Viqi Wagner (ed.), *Recycling* (Farmington Hills, Michigan: Greenhaven Press, 2009), p. 31.
[250] *Ibid.*

TABLE 4-3 CARBON DIOXIDE EMISSION FROM NEW PAPER PRODUCTION VS. RECYCLED PAPER PRODUCTION[251]

Type of Paper	CO_2 per lb.
Virgin paper 0% post-consumer recycled	7.14
33% post-consumer recycled	6.06
50% post-consumer recycled	5.50
66% post-consumer recycled	5.20
100% post-consumer recycled	3.90

Beazley also presented some empirical data taken from an extensive study done by the Environment Defense Fund on paper production and publishing to further establish his claim. The figures show that 100% recycled paper is almost twice as efficient as virgin paper and yet releases almost half of the carbon dioxide emissions.[252] Thus, even though there are opposing views as to whether recycling, in particularly paper recycling, is truly environmentally friendly, it is still evident that paper recycling remains beneficial towards sustainability.

[251] Adam Beazely, 'Recycling is better for the environment', in Viqi Wagner (ed.), *Recycling* (Farmington Hills, Michigan: Greenhaven Press, 2009), p. 31.
[252] *Ibid.*

SECTION TWO - FROM GLOBAL TO A LOCAL CONTEXT

IN THE PREVIOUS SECTION, the issues of the rising of global solid waste and paper usage were presented, as well as the need for sustainability and waste minimization through recycling. These topics were discussed so as to establish the basis for the need and purpose of this research study.

All that were presented in the previous section are also in a global context. However, like architect William McDonough and chemist Michael Braungart pointed out in their book, 'Cradle to cradle: remaking the way we make things' that, "*we recognize that all sustainability (just like all politics) is local.*"[253] Professor Sim Van der Ryn from the University of California Berkeley, together with his co-author, Dr. Stuart Cowan, in their book 'Ecological Design' also said that, "*Sustainability cannot be mechanically replicated under different conditions. It will take endless forms, the very diversity of design possibilities helping to ensure that the whole patchwork quilt of technologies, cultures, and values is sustainable. Bringing sustainability home is about growing a culture of sustainability that is suited to the particularities of place.*"[254] Therefore, this section is about bringing all that were discussed in the previous chapters to the 'home' of this research study, i.e. Singapore.

A brief background about Singapore is first presented for readers that may not be familiar with the nation of Singapore, before moving towards the local government environmental agenda, policies and initiatives, especially in regards to environmental education, which is the focus of this research study.

---

[253] William McDonough and Michael Braungart, 'All sustainability is local', in id., *Cradle to cradle: remaking the way we make thing* (New York: North Point Press, 2002), p. 123.

[254] Sim Van der Ryn and Stuart Cowan, 'Bringing sustainability home', in id., *Ecological Design* (10th Anniversary edn., Washington, D.C.: Island Press, 2007), p. 83.

CHAPTER FIVE - SINGAPORE

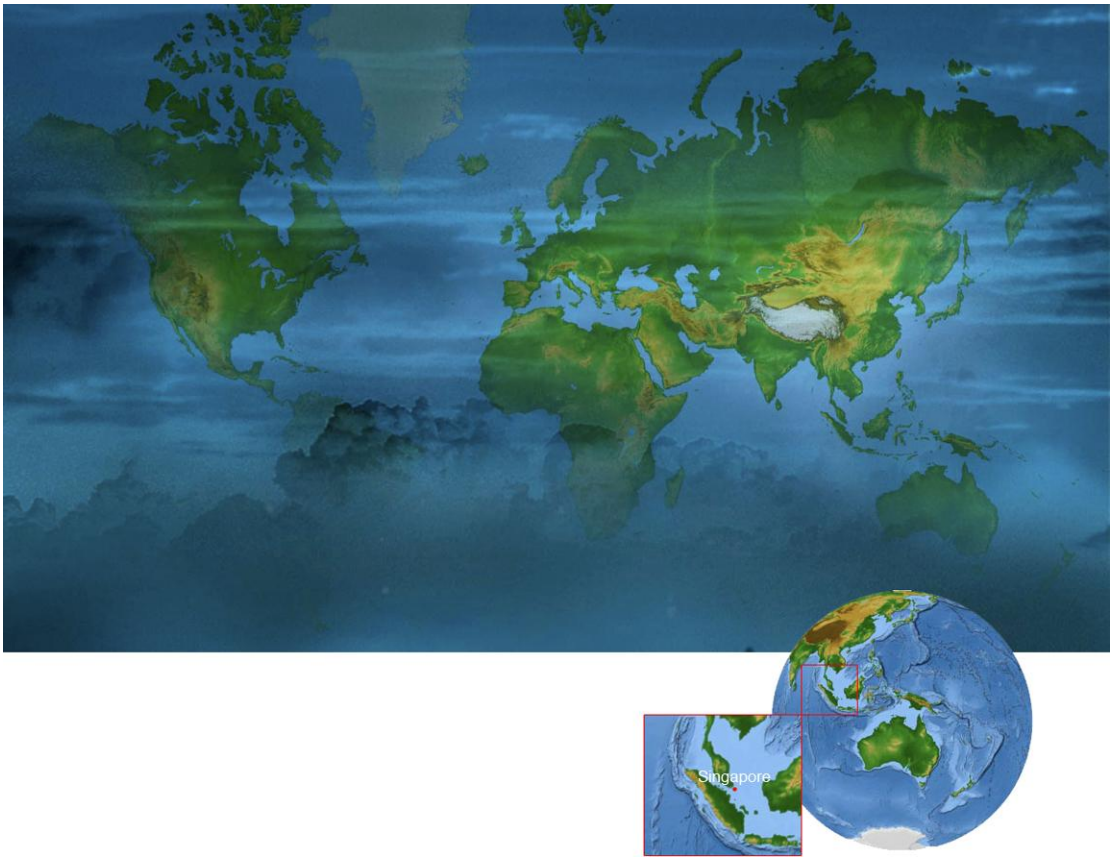


FIGURE 5-1 SINGAPORE IS MORE THAN A RED DOT ON THE WORLD MAP[255]

Singapore is a small tropical island state situated just about one degree north of the Equator and 103 degrees East Meridian.[256] The country is made up of one main island surrounded by about sixty other small isles, mostly to the south. The total land area of the main island is about 617 square kilometres, spanning forty-two kilometres from east to west and twenty-three kilometres north to south.[257] However, in spite

[255] Chua Lee Hoong, 'Executive summary', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. iii.
[256] Simon Tay, 'History', in id., *Over Singapore* (Singapore: Archipelago Press, 1993), p. 17.
[257] Explorer Publishing, 'Geography', in id. *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007), p. 2.

how small and insignificant Singapore is on the world map, she has blossomed into one of Asia's greatest success stories.[258]

FIGURE 5-2 SIR STAMFORD RAFFLES[259]

A BRIEF HISTORY OF SINGAPORE

The history of modern Singapore could be said to have begun in 1819 by the arrival of an official of the British East India Company, named Sir Stamford Raffles.[260] By the eighteenth century, the Europeans were fighting with one another for a footing on the Malay Peninsula so as to facilitate their lucrative Asian trade in opium and spices. In 1786, the British had setup a trading post in the state of Penang in Malaysia, while the state of Malacca was held by the Dutch.[261] Sir Stamford Raffles was ambitious to

[258] Francis Dorai (ed.), 'Smart orderliness', in id. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004), p. 16.
[259] Sean Sheehan, 'A portrait of Sir Thomas Stamford Raffles (1781-1826)', in id., *Portrait of Singapore* (London: New Holland Publishers, 2004), p. 10.
[260] Constance. M. Turnbull, 'The foundation of the Settlement, 1819-1826', in id., *A history of Singapore 1819-1988* (2nd edn., Singapore: Oxford University Press, 1989), p. 6.
[261] Sean Sheehan, *op. cit.*

make Britain the leading trading nation in this nation in this part of the world.[262] So, on 28 January 1819, Sir Stamford Raffles brought his fleet of eight ships to anchor off St John's Island near the Singapore River mouth.[263] When Sir Stamford Raffles learnt that the Dutch were not on the island, and recognizing the strategic geographic location of this island, he quickly signed a treaty with the local Malay rulers to establish Singapore as a free trading port.[264]

FIGURE 5-3 SINGAPORE AS A FREE TRADING PORT

A wax replica of Sir Stamford Raffles signing the 1819 treaty with the Malay rulers of Singapore.[265]

[262] Kwa Guan Chong, Derek Heng and Tan Tai Yong, 'Raffles and the establishment of an East India Company station on Singapore', in id. *Singapore: a 700-year history from early emporium to world city* (Singapore: Oxford Graphic Printers Private Limited, 2009), p. 85.
[263] *Ibid., pp. 86-89.*
[264] Aun Koh and Susan Leong, 'History', id., *Singapore chic: hotels, restaurants, shops,spas, resorts, galleries, bars* (Singapore: Archipelago Press, 2006), p. 15.
[265] Ministry of Information, Communications and the Arts, 'Sentosa', *Singapore Infomap* [website], <http://www.sg/explore/gallery_sentosa.htm>, accessed 20 August 2008.

After Singapore was established as a free trading port, trade increased and the island gradually became the administrative and economic heart of the British Empire in Southeast Asia, overshadowing Penang and Malacca.[266] After some political manoeuvrings, Singapore together with Penang and Malacca formed the Straits Settlement in 1826, and in 1867 the Straits Settlements, became a Crown Colony of the British Empire.[267] Over the next sixty years or so, Singapore enjoyed a great time of peace, growth and prosperity.[268]

FIGURE 5-4 THE JAPANESE OCCUPATION

British Lieutenant-General A. E. Percival signs the surrender at Singapore to Japanese Lieutenant-General T. Yamashita in 1942.[269]

However, when World War II came, the Japanese dismantled the British Colonial rule in Singapore. The Japanese invaded Singapore on February 8, 1942.[270] The British suffered a humiliating defeat and surrendered the island to the Japanese.[271] The next three and a half years of the Japanese occupation was brutal.[272] The daily

[266] Sean Sheehan, 'Early history', in id., *Portrait of Singapore* (London: New Holland Publishers, 2004), p. 10.
[267] Angela Milligan, 'Development', in id., *Singapore - Culture Smart!: a quick guide to customs and etiquette* (London: Kuperard, 2006), pp. 27-28.
[268] Aun Koh and Susan Leong, 'History', id., *Singapore chic: hotels, restaurants, shops, spas, resorts, galleries, bars* (Singapore: Archipelago Press, 2006), p.17.
[269] David O. William, 'Prisoners of Japan', in New Zealand War History Branch, *Episodes & Studies Volume 1* (Wellington: Historical Publication Branch, 1948), p. 13.
[270] Francis Dorai (ed.), 'Reign of terror', in id. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004), p. 24.
[271] Explorer Publishing, 'History', in id. *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007), p. 2.
[272] Raymond Flower, 'The Syonan interlude: Miseries and illusions', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 231.

executions and rising food cost as food was rationed badly affected the lives of people in Singapore.[273]

The Japanese occupation finally came to an end in August 1945 after the United States of America dropped the first atomic bomb upon Hiroshima, Japan on 6 August and was followed by the second upon Nagasaki on 9 August, and on 15 August, the emperor of Japan announced his surrender.[274] On August 21, Singapore once again returned under the colony of the British Empire.[275] However, like Professor Robin Ramcharan from the University of Toronto suggested in his book that, "*The Japanese occupation of Singapore and Southeast Asia unleashed social forces that would lead to Singapore's emergence as an independent state.*"[276]

In June 1948, the people of Singapore found themselves with yet another war on their doorstep. This time, it was against the backdrop of a young man by the name of Lee Kuan Yew, who has returned home with a double-first from Cambridge University.[277] By the 1950s, there was much pressure for independence in Singapore, and in 1959, the British Parliament passed an act approving a new constitution of self-governing state.[278] A general election was set in May 1959, and a new political party, the People's Action Party (PAP) led Mr. Lee Kwan Yee, won the election, and Mr. Lee became the first Prime Minister of Singapore.

---

[273] Sean Sheehan, ''The war years', in id., *Portrait of Singapore* (London: New Holland Publishers, 2004), p. 13.

[274] Anthony J. Stockwell, 'World War II and Japanese Occupation', in Nicholas Tarling (ed.), *The Cambridge history of Southeast Asia* (Vol. 2, Cambridge; New York: Cambridge University Press, 1992), p. 333.

[275] Francis Dorai (ed.), 'Reign of terror', in id. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004), p. 24.

[276] Robin Ramcharan, 'Introduction', in id., *Forging a Singaporean statehood, 1965-1995: the contribution of Japan* (London: Kluwer Law International, 2002), p. 3.

[277] Raymond Flower, 'The Syonan interlude: Miseries and illusions', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 234.

[278] Francis Dorai (ed.), 'Independence', in id. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004), pp. 24-25.

FIGURE 5-5 MR. LEE KUAN YEW

The first Prime Minister of the Republic of Singapore from 1959 to 1990.[279]

Mr Lee was only thirty-six when he became the first Prime Minister of Singapore. No Asian leader had reached the top so young.[280] Mr. Lee's early years were marked by the fight for complete independence from the British. In order to achieve that, he sought a merger with Malaya.[281] In 1963, Singapore and Malaya formed a merger independent of Britain. But the merger soon ran into trouble as Mr. Lee strove to transform Singapore into the 'New York of Malaysia'.[282] In 1964, the PAP refused to be confined to Singapore and participated in elections in the Malay Peninsula.[283] However, worse was the racial tension. The PAP's entering into the Malaysian

[279] Raymond Flower, 'In 1960, the fires of political change had been lit but had not yet settled to a steady glow. Malaya had shed colonialism, Singapore achieved self rule, but on the road ahead was merger and independence. Here during May Day Celebrations of 1960, the cry was 'Merdeka – Freedom!', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 349.

[280] Thayil J. S. George, 'The making of a city state', in id., *Lee Kuan Yew's Singapore* (2nd edn., Singapore: Eastern Universities Press, 1984), p.15.

[281] Sean Sheehan, ''The war years', in id., *Portrait of Singapore* (London: New Holland Publishers, 2004), p. 13.

[282] Raymond Flower, 'The emergence of Lee Kuan Yew', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 240.

[283] Simon Tay, 'History', in id., *Over Singapore* (Singapore: Archipelago Press, 1993), p. 28.

political scene was viewed by the Malaysia's Malays as a Chinese bid to challenge Malay supremacy. The discord between the Malays and Chinese culminated in two racial riots that broke out in Singapore, and set the stage for a split of the merger.[284]

On August 9, 1965, it was announced that Singapore would be separated from Malaysia,[285] and the Republic of Singapore was proclaimed as a member of the Commonwealth, and a month later she was admitted to the United Nations.[286]

FIGURE 5-6 MODERN SINGAPORE

Brilliant lights illuminate thousands of cargo containers in the port of Singapore, one of the largest and busiest in the world today.[287]

---

[284] Francis Dorai (ed.), 'Divisive differences', in id. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004), p. 27.

[285] Simon Tay, 'History', in id., *Over Singapore* (Singapore: Archipelago Press, 1993), p. 28.

[286] Raymond Flower, 'The emergence of Lee Kuan Yew', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 241.

[287] John Stanmeyer, 'Almost eclipsing the skyscrapers in the background, brilliant lights illuminate thousands of cargo containers in this port in Singapore's harbor. Singapore has one of the largest and busiest ports in the world.', *National Geographic Society* [website], published online 01 Nov. 2007, <http://ngm.typepad.com/our_shot/november-1-2007.html> , accessed 27 Aug. 2008.

POST INDEPENDENCE MODERN SINGAPORE

Once Singapore had attained its shaky independence, Prime Minister Lee had to rally the citizens of Singapore to a seemingly impossible task: to build a nation out of a tiny island state that is beset by her unfriendly neighbours and devoid of natural resources.[288] In order to overcome the odds, Mr. Lee built his government along the idea of Greek philosopher Plato, that a perfect city-state should be run by a philosopher-king and the guardian class, whose right to rule is legitimised by the rest of the society.[289] Mr. Lee emphasized on a tough and uncorrupted government that focuses on stability and productivity.[290]

Under the leadership of Mr. Lee, Singapore transformed from an island with barely any natural resources, little agricultural land, inadequate fresh water supplies and limited technology, to today, one of the most technologically advanced and wealthy countries in Southeast Asia.[291] Since its independence in 1965, Singapore's economy has grown by an average of 9 per cent each year.[292] And when Prime Minister Lee passed on the leadership to Mr. Goh Chok Tong in 1990, the citizens of Singapore were housed, educated, affluent and morale was high.[293]

---

[288] Raymond Flower, 'An island state comes to age', in id., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984), p. 252.
[289] Explorer Publishing, 'Modern Singapore', in id. *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007), p. 19.
[290] Jill A. Laidlaw, 'Modern Singapore', in id., *Singapore* (London: Dorling Kindersley Limited, 2000), p. 21.
[291] Sean Sheehan, 'Modern Singapore', in id., *Portrait of Singapore* (London: New Holland Publishers, 2004), p. 14.
[292] Aun Koh and Susan Leong, 'Modern Singapore', id., *Singapore chic: hotels, restaurants, shops, spas, resorts, galleries, bars* (Singapore: Archipelago Press, 2006), pp. 19-20.
[293] Explorer Publishing, *op. cit.*, pp. 19-20.

FIGURE 5-7 SUSTAINABLE SINGAPORE

A vision to become a city that offers a quality environment for the current and future generations of Singaporeans.[294]

TOWARDS A MODEL GREEN CITY

Very few nations in the world has grown and modernized as quickly as Singapore. The free market economy of Singapore has accomplished an almost uninterrupted growth since its independence in 1965. Such progress was exceptional and has therefore been often cited as a model of success for many emerging nations.[295] Singapore is also often cited as an example of sound environmental management in spite of its rapid industrialization and urbanization.[296] The Singapore government and its environmental authorities have responded to the challenges of fast-paced industrial development and rapid urbanization by building a Green City – '*a city with a well-designed land-use and a comprehensive and sophisticated environmental infrastructure.*'[297]

---

[294] Ministry of the Environment and Water Resources, 'Sustainable Singapore', *Ministry of the Environment and Water Resources* [website], published online Apr. 2005, <http://app.mewr.gov.sg/web/Contents/ContentsSSS.aspx?ContId=1034>, accessed 29 Aug. 2008.

[295] Explorer Publishing, 'Model of success', in id., *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007), p. 4.

[296] Ooi Giok Ling, 'Singapore – Assessing the progress towards sustainability', in id., *Sustainability and cities: concept and assessment* (Singapore: Institute of Policy Studies; Hackensack, New Jersey: World Scientific Publishing Co., 2005), p. 80.

[297] Azra Moiz, 'The Singapore Green Plan – A new approach', in id., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993), p. 9.

Professor Ooi Giok Ling from the Institute of Policy Studies of Singapore, described in one of her publications, "*Unlike the earlier newly industrializing economies of East Asia – South Korea, Taiwan and Hong Kong – that had adopted the approach of industrializing first and cleaning up later, Singapore decided at the beginning that the cleaning up would proceed in tandem with the planned economic growth and development.*"[298] The Singapore government truly believes that economic growth and environmental protection are mutually supportive.[299]

THE SINGAPORE GREEN PLAN

The 'Singapore Green Plan' was first presented at the Earth Summit in June 1992.[300] It describes the policy directions that Singapore will take towards realizing its long-term vision of becoming a green city. The Singapore Green Plan looks at all areas of environmental concerns, and proposes ways to preserve, protect and enhance the environment of Singapore for the future generations.[301]

One of the major environmental concerns addressed in the Singapore Green Plan was on Solid Waste Management. It is recorded that in 1991, as a nation, Singapore generated about an average of 5,900 tons of solid waste every day. The Industrial and commercial waste made up fifty-one percent of the waste, while domestic and trade waste made up the remainder. It was also projected in the Singapore Green Plan that as the population of Singapore moves to a higher standard of living, the amount of refuse disposed is estimated to rise to about 8,000 tons per day by Year 2000.

---

[298] Ooi Giok Ling, 'Singapore – Assessing the progress towards sustainability', in id., *Sustainability and cities: concept and assessment* (Singapore: Institute of Policy Studies; Hackensack, New Jersey: World Scientific Publishing Co., 2005), p. 80.

[299] Explorer Publishing, 'Environmental issues', in id., *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007), p. 16.

[300] Azra Moiz, 'The evolution of the Singapore Green Plan', in id., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993), pp. 9-11.

[301] Ministry of the Environment, 'Introduction', in id., *The Singapore Green Plan: Towards a model green city* (Singapore: SNP Publishers, 1992), p. 1.

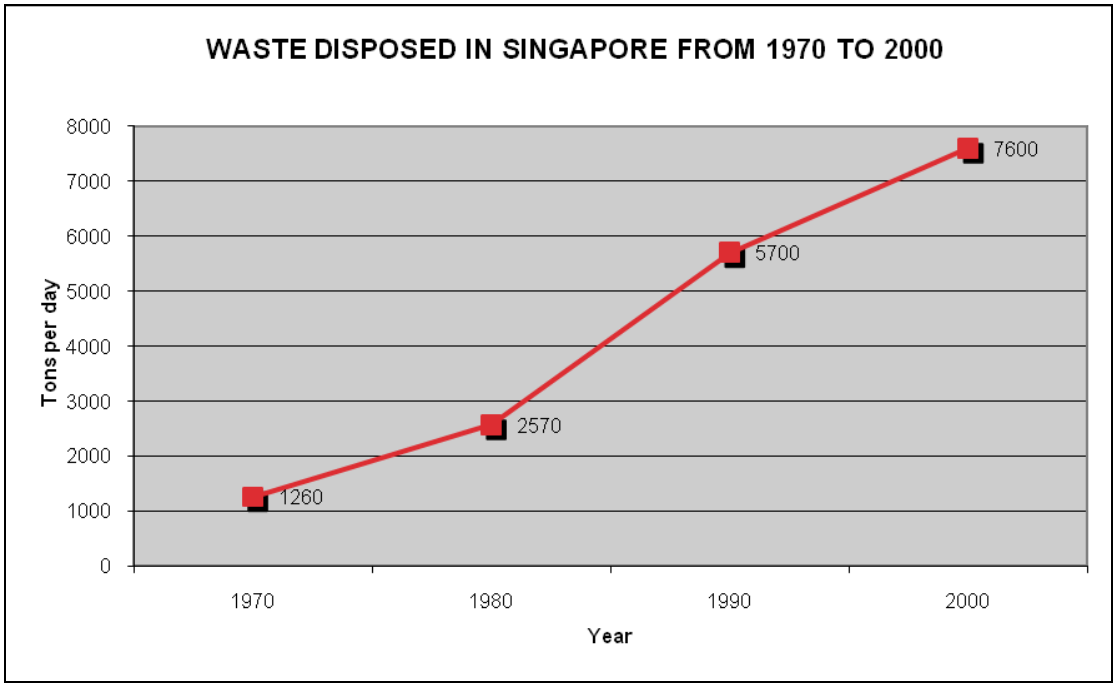


FIGURE 5-8 THE SIX-FOLD INCREASE IN WASTE DISPOSED IN SINGAPORE FROM YEAR 1970 TO 2000[302]

True enough, the amount of solid waste generated in Singapore reached an average of 7,600 tons per day in 2000. The amount of refuse disposed increased more than six times in the last three decades, from 1970 to 2000. As of 2006, an estimated 90 percent of the disposed solid waste was sent for incineration at one of the four incineration plants in Singapore. The non-incinerable waste, together with the incineration ash from the plants, was disposed off at an offshore landfill. However, if this rapid escalation of waste persists, it will mean that a new incineration plant would have to be built in every 5 to 7 years and a 350-hectare landfill every 25 to 30 years. This poses an alarming prospect for a small, land-scarce island as Singapore.[303]

---

[302] Loh Ah Tuan, 'Singapore National 3R Strategy', *3R Workshop on Effective Waste Management and Resource Use Efficiency in East and Southeast Asia - Asian Development Bank* [website], published online 15 Feb. 2007, <http://www.adb.org/Documents/Events/2007/Effective-Waste-Management/Loh-Ah-Tuan-presentation.pdf>, accessed 03 Sep 2008.

[303] Foo Siang Luen (ed.), 'Reduce, reuse and recycle', in id. (ed.), *The Singapore Green Plan 2012* (2006 edn., Singapore: Ministry of the Environment and Water Resources, 2006), p. 38.

FIGURE 5-9 SINGAPORE'S LANDFILL

Pulau Semakau - the first and only offshore landfill in Singapore[304]

Like journalist and filmmaker Heather Rogers described, "*As our landfills overflowed our throwaway mentality came back to haunt us: we now were confronted with a huge waste disposal problem. Ironically, we did not see our folly as a waste of resources, or even as a detriment to ecosystems, but rather as a pile of litter, for which there was no more room at the dump.*"[305] The Singapore government recognizes that the reduction of waste generation at source and recycling are the keys to Solid Waste Management for the future.[306]

[304] Francesca de Châtel, 'The island paradise built on a garbage dump', *Cable News Network* [website], published online 26. Jul. 2007, <http://edition.cnn.com/2007/TECH/07/26/ji.semakaulandfill/>, accessed 05 Sep. 2008.

[305] Heather Rogers, 'The golden age of waste', in id., *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005), pp. 103-105.

[306] Azra Moiz, 'Waste minimisation and recycling', in id., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993), pp. 33-35.

FIGURE 5-10 THE SINGAPORE GREEN PLAN 2012

The Singapore Green Plan 2012, released in 2002, mapped out the strategic directions for Singapore to preserve, protect and enhance the environment and water resources for the next 10 years.[307]

In 2002, the Ministry of the Environment of Singapore published the Singapore Green Plan 2012 (SGP2012) in response to the World Summit on Sustainable Development at Johannesburg. The document states that, "*SGP 2012 begins with a focus on optimizing the use of Singapore's limited land. Our limited land availability requires us to pursue a "zero landfill" objective in the longer term - an admittedly ambitious but not impossible target. Towards that end, a national waste recycling programme, with a target to achieve 60 percent recycling by 2012, began in 2001, bringing the means to recycle closer to homes and workplaces. In tandem with this, we hope to minimize waste generation and reduce our need for additional incineration plants, from the current one every 5 to 7 years, to one every 10 to 15 years, and longer if possible.*"[308] And in the 2006 revised version of the SGP2012,

[307] Ministry of the Environment and Water Resources, 'Three-yearly review of Singapore Green Plan 2012', *Ministry of the Environment and Water Resources* [website], published online Apr. 2005, <http://app.mewr.gov.sg/web/Contents/Contents.aspx?Yr=2005&ContId=624>, accessed 12 Sep. 2008.

[308] Chua Lee Hoong, 'Averting a wasteland', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. iv.

the Singapore's environmental authorities once again emphasized that, "*Recycling is one sure way to cut down the amount of waste headed for Semakau Landfill or the incineration plants.*"[309]

FIGURE 5-11 RECYCLING BINS IN SINGAPORE[310]

RECYCLING IN SINGAPORE

Recycling in Singapore has been practiced since its earliest days by the rag-and-bone men (commonly known to locals as the 'Karung Guni' men). These men go around residential estates in Singapore to collect old newspapers, rags and scrap, and subsequently sell what they have collected to middlemen for profit.[311] A pilot modern recycling scheme has been carried out in 1990, where recycling bins have been set up in six Town Councils, three private housing estates, thirty-four

[309] Foo Siang Luen (ed.),, 'Reduce, reuse and recycle', in id. (ed.), *The Singapore Green Plan 2012* (2006 edn., Singapore: Ministry of the Environment and Water Resources, 2006), p. 40.
[310] Wan Zhong Wei, 'Recycle - Or is it?', *Flickr* [website], updated 16. Aug. 2007, <http://www.flickr.com/photos/wanzw/1138691836/>, accessed 18 Aug. 2008.
[311] Azra Moiz, 'Cutting household waste, in id., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993), pp. 35-36.

condominiums and a number of schools, offices, factories and petrol stations.[312] A 'National Recycling Programme' (NRP) was launched in April 2001 to bring the means to recycle nearer to the consumers. Under this program, Singapore residents can put their recyclables in bags or crates outside their home and they will be collection every fortnight.[313]

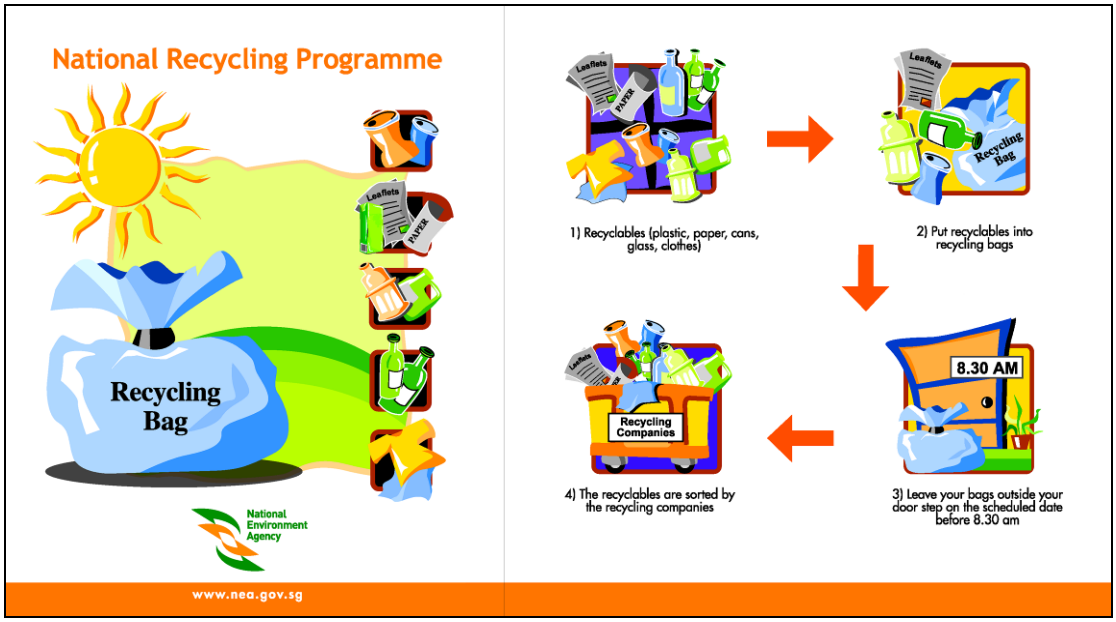


FIGURE 5-12 THE NATIONAL RECYCLING PROGRAM IN SINGAPORE

The 'National Recycling Programme' launched in April 2001 by the National Environmental Agency of Singapore.[314]

[312] Azra Moiz, 'Cutting household waste, in id., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993), pp. 35-36.

[313] Foo Siang Luen (ed.),, 'Recycling up = waste down', in id. (ed.), *The Singapore Green Plan 2012* (2006 edn., Singapore: Ministry of the Environment and Water Resources, 2006), pp. 40-41.

[314] National Environment Agency, 'NRP brochure'*, National Environment Agency* [website], published online 20 Sep. 2006, <http://www.nea.gov.sg/cms/rcd/NRP_brochure.pdf>, accessed 22 Aug. 2008.

TABLE 5-1 SOLID WASTE MANAGEMENT STATISTICS OF YEAR 2005-2007[315]

Solid Waste Management	Unit	2005	2006	2007
Total waste generated	Million tons/year	5.01	5.22	5.60
Total waste recycling	Million tons/year (%)	2.47 (49%)	2.66 (51%)	3.03 (54%)
Total waste incinerated	Million tons/year (%)	2.27 (45%)	2.33 (45%)	2.38 (43%)
Total waste land-filled	Million tons/year (%)	0.27 (6%)	0.23 (4%)	0.19 (3%)

The results of the recycling initiatives are beginning to show. The overall recycling rate in Singapore began to rise from 40% to 49% from 2000-2005. By 2007, a total of 54% million tons of waste was generated, of which about 54% is recycled.[316] This shows that Singapore certainly has the potential of reaching its targeted 60% overall waste recycling rate by 2012.[317]

[315] Ministry of the Environment and Water Resources, 'Key Environmental Statistics 2008', *Ministry of the Environment and Water Resources* [website], updated 04 Jul. 2008, <http://app.mewr.gov.sg/data/ImgUpd/KES2008.pdf>, accessed 04 Jul. 2008.

[316] *Ibid.*

[317] Foo Siang Luen (ed.), 'Targets', in id. (ed.), *The Singapore Green Plan 2012* (2006 edn., Singapore: Ministry of the Environment and Water Resources, 2006), p. 43.

FIGURE 5-13 STUDENTS LEARNING ABOUT ENVIRONMENTAL PROTECTION THROUGH ENVIRONMENTAL EDUCATION PROGRAMS IN SCHOOLS[318]

ENVIRONMENTAL EDUCATION

Besides the emphasis on recycling, the Singapore government also recognizes that the national schools play a vital role in cultivating environmental responsibility amongst the students in Singapore.[319] It is stated in the 'Singapore Green Plan – Action Programme' that, "*The foundation for the construction of a society with the knowledge and concern to safeguard our environment is laid in the schools. Schoolchildren age 7-18 (primary to pre-university) are an important target group. They are at their most receptive years and, through properly structured curricula, can be exposed to increasingly complex environmental issues as their intellectual and comprehension powers develop. These issues, being of the world around them, are inherently interesting. With proper presentation of materials, their natural curiosity and wonder will be whetted and there will be good retention of the issues and values taught. Schoolchildren can also play a helpful role in disseminating information to their homes and families.*"[320] Environmental issues are today woven into the teaching curriculum of all national schools. The national schools are also taking part in numerous programs run by the Ministry of the Environment and the Singapore

[318] Chua Lee Hoong, 'Everyman's earth and every country's too', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. 33.

[319] Chua Lee Hoong, 'Environmental education', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. 35.

[320] Azra Moiz, 'Through the formative years', in id., *The Singapore Green Plan: action programmes* (Singapore: Times Editions, 1993), p. 14.

Environmental Council, in conjunction with Earth Day, World Environment Day and Clean and Green Week.[321]

[321] Chua Lee Hoong, 'Environmental education', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. 35.

CHAPTER SIX - SUSTAINABILITY AND RECYCLING IN SINGAPORE'S SCHOOLS

The Singapore government believes that cultivating the knowledge of the scientific and social significance of the environment is the first step in the founding of an environment-friendly society.[322] It has, together with other non-governmental environmental agencies, initiated a wide range of environmental education programs in school to nurture a greater sense of environmental consciousness amongst the students.

TABLE 6-1 ENVIRONMENTAL EDUCATION PROGRAMS IN SINGAPORE NATIONAL SCHOOLS[323]

Journey Through Our Sewers This program focuses on efforts by the government to improve and manage the wastewater systems in Singapore over the years. It highlights how wastewater is collected, channeled to and treated at the wastewater reclamation plants. Students will get to visit a Public Utilities Board (PUB) installation, watch an educational video, and learn from an activity book under this program.	**"How Green is Your School?"** This is a green audit designed to promote awareness of resource conservation in schools. Students calculate the school's usage of water and electricity, and the amount of waste generated. From these findings, they suggest ways to cut down on unnecessary usage, and to reduce and recycle garbage that is generated. The audit has been tied up with an award scheme for participating schools. There are five tiers of awards and schools have the opportunity to upgrade themselves as their environmental performance improves.
Seashore Life Program Through a hands-on clean-up session at the beach, this program teaches students the importance of keeping the beaches clean so that the waters will	**National Youth Achievement Award Council's Youth Environmental Award** Established in 1998, the award recognizes young people (aged 14 to 25) who have distinguished themselves

[322] Azra Moiz, 'Building environmental consciousness', in id., *The Singapore Green Plan: action programmes* (Singapore: Times Editions, 1993), p. 13.

[323] Chua Lee Hoong, 'Programmes', in id., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002), p. 38.

not be polluted.

in the area of environmental protection and nature conservation in Singapore.

ENVIRONMENTAL AWARENESS AND CONSCIOUSNESS OF SINGAPORE STUDENTS

In 2006, Forbes Research, one of Asia Pacific's most active full-service research companies, conducted a survey on behalf of Singapore's National Environment Agency to assess the level of knowledge, awareness, beliefs and practices among the local school students with respect to the environment. A total of 1,860 students from 30 primary schools, 39 secondary schools, 6 technical education institutions, and 7 centralised institutes/junior colleges, were involved in this survey. It was found that the students in Singapore are highly aware of environmental issues, scoring a high 90 out of 100 on the knowledge index. In addition, nearly 80 per cent agreed that environment practices and issues will become an integral part of their lives in future.[324] However, when it came to putting the knowledge into practice, only 60 per cent of the students were doing so.[325] Dr. Amy Khor, Senior Parliamentary Secretary of Singapore's Ministry of Environment and Water Resources, "*It is important that we actually inculcate awareness and turn this awareness into practice. We need to promote this practice, turn this awareness into practice for that 40 percent. It is a significant number and we need to do a lot more work on this; I think the focus should be activities that turn knowledge into practice.*"[326]

In another survey study conducted by the National University of Singapore with 445 local students from six secondary schools, two junior colleges, a pre-university centre

[324] National Environment Agency, 'Awareness of environment issues among students yet to be translated into action', *National Environment Agency* [website], published online 14 Nov. 2006, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2799>, accessed 16 Jul. 2008.

[325] Noor Mohd. Aziz, 'Singapore students aware of environmental issues', *Channel NewsAsia* [website], published online 14 Nov. 2006, <http://www.channelnewsasia.com/stories/singaporelocalnews/view/241237/1/.html>, accessed 16 Jul. 2008.

[326] *Ibid.*

and a tertiary institution,[327] [SEE APPENDIX A FOR THE LIST OF INSTITUTIONS AND THE BREAKDOWN OF THE STUDENT POPULATION SURVEYED] it is found that of the various Singapore government environmental policies, the most popular response amongst the Singapore students is the "Clean and Green Week" (CGW).[328] The CGW, launched in 1990, is an one-week-long campaign that runs annually every November. It is targeted at promoting awareness and appreciation for a clean and green environment through activities and events that allow Singaporeans to experience hands-on how to care for the environment as well as explore themes and issues relevant to the environment.[329] What follows as the second most popular student response is recycling.

[327] Victor R. Savage and Sharon Lau, 'Green issues: official policies and student awareness', in Clive Briffett and Sim Loo Lee (eds.), *Environmental issues in development and conservation* (Singapore: SNP Publishers, 1993), p. 13.
[328] *Ibid.*, p. 18.
[329] Naidu Ratnala Thulaja, 'Clean and Green Week', *National Library Board* [website], published online 09 Jan. 2004, <http://infopedia.nl.sg/articles/SIP_395_2005-01-17.html>, accessed 18 Jul. 2008.

TABLE 6-2 STUDENTS' AWARENESS TO GOVERNMENT ENVIRONMENTAL POLICIES IN SINGAPORE[330]

No.	Government Policies In Singapore	1st Response	2nd Response	Average (%)
1.	Clean and Green Week	28.3	7.0	17.6
2.	Recycling Campaign	11.7	6.7	9.2
3.	No Smoking Campaign	6.3	4.5	5.4
4.	Anti-Littering Campaign	5.6	4.3	5.0
5.	Use of Legislation	3.6	4.3	3.9
6.	Tee Planting Programs	3.6	2.3	3.0
7.	Ozone Friendly Campaigns	1.8	3.8	2.8
8.	Use of Unleaded Petrol	1.6	2.3	1.9
9.	Control of Car Emission Level	1.4	1.8	1.6
10.	Save the Earth Campaign	1.6	1.6	1.6
11.	Saving Water and Electricity Campaign	0.9	0.9	0.9
12.	Preservation of Wildlife and Nature	1.1	0.5	0.8
13.	Banning of Chewing Gum	0.7	0.7	0.7
14.	Adopting a Beach Program	0.9	0.2	0.6
15.	Control Car Populations – COEs	0.7	0.2	0.4
16.	Singapore Green Plan	0.2	0.5	0.3
17.	Cleaning of Singapore River	0.2	0.2	0.2
18.	No Response	30.6	58.2	44.4
	Total	100.0	100.0	100.0

[330] Victor R. Savage and Sharon Lau, 'Green issues: official policies and student awareness', in Clive Briffett and Sim Loo Lee (eds.), *Environmental issues in development and conservation* (Singapore: SNP Publishers, 1993), p. 19.

When the students were asked to name two products that could be recycled, paper emerged as the most cited item for recycling. This is unsurprising as students work most with paper products. Interviews with the local schoolteachers who are involved in the green movement also revealed that the recycling of paper is one of the main environmental activities in schools.[331]

TABLE 6-3 STUDENTS' RESPONSE TO PRODUCTS THAT CAN BE RECYCLED[332]

No.	Products for Recycling	Product One (%)	Product Two (%)	Average (%)
1.	Paper Products	64.9	22.3	43.6
2.	Tin/Metals	18.2	39.6	28.9
3.	Plastic Products	5.2	12.1	8.7
4.	Glass Bottles	-	16.2	8.7
5.	Styrofoam Products	9.4	0.5	5.0
6.	Batteries	0.9	1.8	1.4
7.	Water	-	1.8	0.9
8.	Rubber	-	0.2	0.1
9.	No Response	1.4	5.6	3.5
	Total (%)	100.0	100.0	100.0

In order to ascertain the quantity of paper used in different schools, a quantitative survey has been conducted for this research. All of the data collected were based on the statistics that the schools submitted to the Singapore Environment Council (SEC) for the Schools' Green Audit Award. Five schools were then randomly selected from

[331] Victor R. Savage and Sharon Lau, 'Green issues: official policies and student awareness', in Clive Briffett and Sim Loo Lee (eds.), *Environmental issues in development and conservation* (Singapore: SNP Publishers, 1993), p. 18.
[332] *Ibid.*, p. 21.

each level of education (Primary, Secondary and Junior College) to obtain a general quantity of paper used in the local schools over a span of three year (2004-2006). [SEE APPENDIX B FOR THE LIST OF INSTITUTIONS SURVEYED]

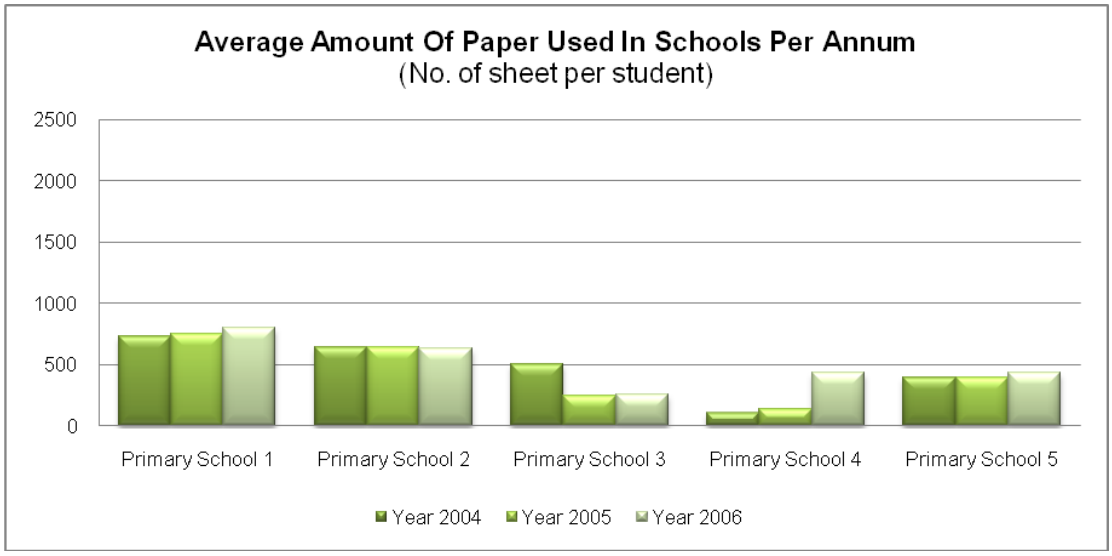


FIGURE 6-1 QUANTITY OF PAPER USED IN FIVE PRIMARY SCHOOLS FROM YEAR 2004 TO 2006

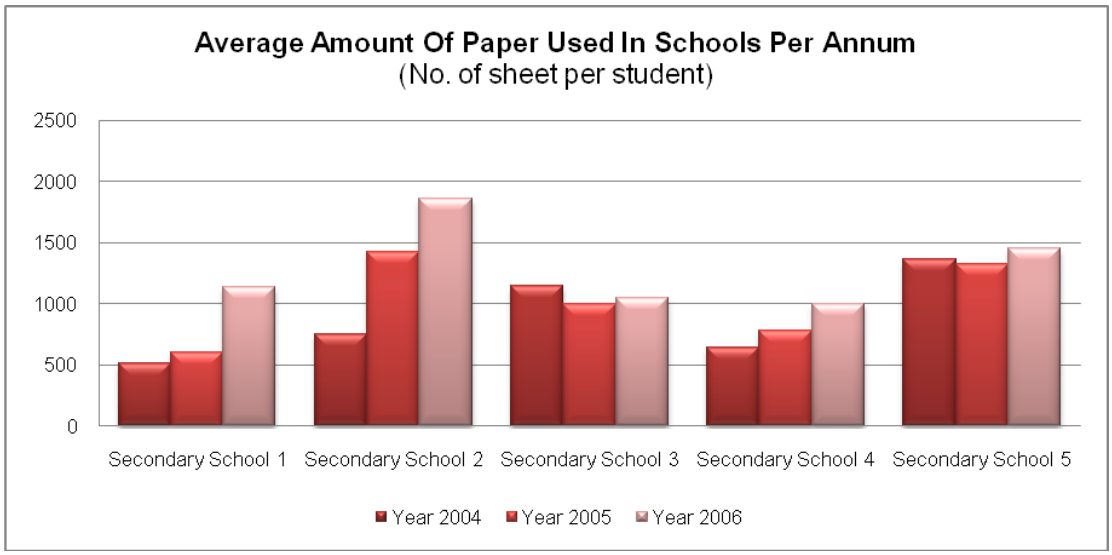


FIGURE 6-2 QUANTITY OF PAPER USED IN FIVE SECONDARY SCHOOLS YEAR FROM 2004 TO 2006

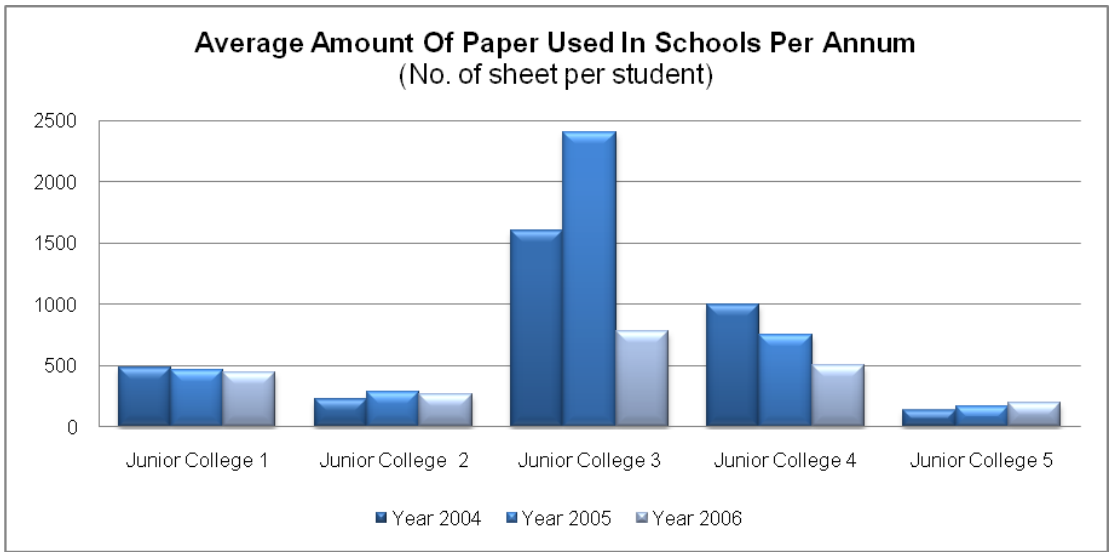


FIGURE 6-3 QUANTITY OF PAPER USED IN FIVE JUNIOR COLLEGES FROM YEAR 2004 TO 2006

Based on the data collected, it is founded that the secondary schools are, on the average, the largest consumer of paper; averaging about one thousand sheets per student annually from 2004 to 2006. This is very likely because students in the secondary schools are given more assignments compared to students in the primary schools, while students in the junior colleges are taking less curriculum subjects than those in the secondary schools. The data collected also confirms that the students in Singapore are truly consuming a large quantity of paper, and it is especially true for students in the secondary schools. It is therefore unsurprising that the recycling of paper is one of the key environmental activities in the local schools.

RECYCLING PROGRAM IN SCHOOLS

The National Environmental Agency (NEA) together with the Singapore Environment Council and Singapore's waste recyclers launched a structured recycling program for the schools in Singapore in 2002. The recycling program involves the setting up of a Recycling Corner in the school where recycling bins for paper, aluminum drink cans

and plastic bottles are placed. Educational materials such as posters and booklets are also made available for the students. The aim of this program is to inculcate the habit of recycling amongst the students. NEA also works closely with the local schools in organizing talks, exhibitions, activities and competition to ensure the sustainability of the recycling program.[333]

FIGURE 6-4 RECYCLING CORNER IN SCHOOL[334]

NEA also launched a new schools recycling outreach programme during the Clean & Green Week Schools Carnival in 2005. This program, which is targeted at the local primary and secondary schools, with the junior colleges, aims to involve the schools in reaching out not only to the school community but also their neighbouring residents towards better environmental awareness and practices on waste minimization and recycling.[335]

The program comprises of two phases: 'Within school boundary' and 'Outside school boundary.' The first phase of the program is to encourage the school community to establish a more structured recycling program within the school premises.

[333] National Environment Agency, 'Recycling programme', *National Environment Agency* [website], updated 08 May 2008, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2306>, accessed 08 Aug. 2008.
[334] National Environment Agency, 'Recycling outreach programme 2008', *National Environment Agency* [website], updated 08 May 2008, <www.nea.gov.sg/cms/3ppd/recycling_cip/Recycling%20Outreach%20Programme%202008.ppt>, accessed 08 Aug. 2008.
[335] *Ibid.*

Thereafter, the schools can move on to the second phase, which is to reach out to the community in the vicinity of the schools and to educate them on waste minimization and recycling.[336]

FIGURE 6-5 SCHOOLS RECYCLING OUTREACH PROGRAM[337]

Under this programme, students are required to carry out environmental awareness activities such as a play or skit on waste minimization or recycling, exhibition of environmental projects by the students, as well as interactive booth showcasing paper making demonstration, art and craft works, and game booths.[338]

Based on the earlier findings, it is evident that there lies a huge potential to consider how the waste paper in schools can be recycled into useful materials and resources for the various activities in the Schools Recycling Outreach Program.

---

[336] National Environment Agency, 'School recycling outreach programme', *National Environment Agency* [website], updated 08 May 2008, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2678>, accessed 08 Aug. 2008.

[337] *Ibid.*

[338] National Environment Agency, 'School recycling outreach programme pamphlet', *National Environment Agency* [website], updated 08 May 2008, <http://www.nea.gov.sg/cms/3ppd/recycling_cip/rop%20pamphlet%202007.pdf>, accessed 08 Aug. 2008.

SECTION THREE - DESIGN FOR SUSTAINABILITY

THE INDUSTRIAL DESIGN SOCIETY OF AMERICA (IDSA) STATES THAT, "*Design can enable people to meet our needs without destroying the natural world. Ecological design can reduce costs, improve system usability, and inspire people to act for the benefit of our natural environment and the quality of life of human society in the future*", and "*Designers have enormous potential to reduce ecological damage*".[339]

In the late twentieth century, although the quality of human life has been greatly improved through inventions and new tools, yet the existing approach in product development has caused much negative impact on the environment. Thus, designers began to focus on devising strategies for creating a more sustainable approach to product development.[340] Design for Sustainability, often used interchangeably with related terms such as green design, eco-design, sustainable design or design for environment, is evolved from the attempt to incorporate environmental considerations into design.[341]

From the research done in the previous two sections, this section will discuss the conceptualizing of a new waste paper recycling system that is more sustainable and educational for the schools in Singapore.

---

339 Industrial Design Society of America, 'Designing to protect our planet', *Industrial Design Society of America Ecodesign* [website], <http://www.idsa.org/whatsnew/sections/ecosection/index.html>, accessed 29 Sep. 2008.

340 Daniel F. Cuffaro and Douglas Paige, 'Sustainable Design', in Daniel F. Cuffaro (ed.), *Process, materials, and measurements: all the details industrial designers need to know but can never find* (Gloucester, Massachusetts: Rockport Publishers, 2006), p.172.

341 Beatrice K. Otto, 'The essentials of sustainability and sustainable design', *Design Council* [website], published online 14. Nov. 2006, <http://www.designcouncil.org.uk/en/About-Design/Business-Essentials/Sustainability/>, accessed 29 Sep. 2008.

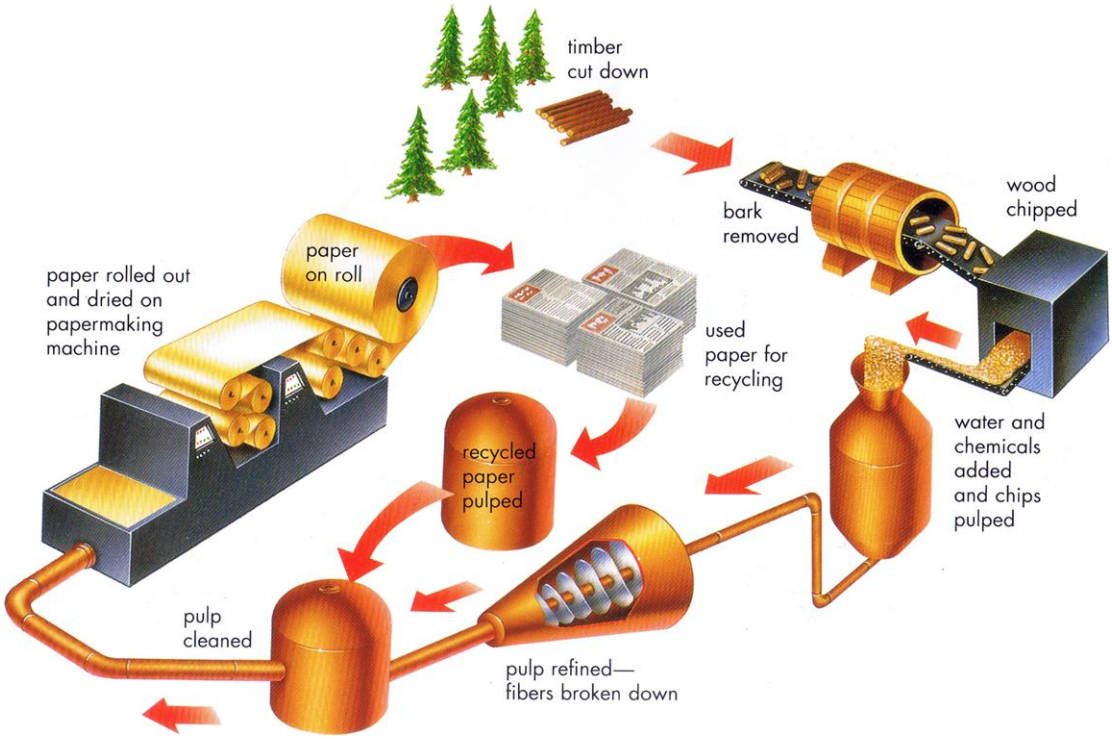


FIGURE 7-1 HOW PAPER IS MADE AND RECYCLED IN THE INDUSTRY

Used paper taken from recycling centres is pulped and then mixed in with the ordinary pulp to make new paper.[342]

Other than the industrial way of recycling paper [SEE FIGURE 7-1], used paper can also be made into new recycled paper through the traditional handmade-papermaking process. The process is simple and can be picked up by students who are even in the primary schools.

The initial stage of the papermaking process is to first collect the waste paper that are be recycled and also to setup a suitable papermaking workshop or studio within the school premises.

[342] Rosie Harlow and Sally Morgan, 'Plenty of paper', in id., *Garbage and recycling* (Boston, Massachusetts: Kingfisher, 1995), p. 19.

FIGURE 7-2 PREPARING THE INGREDIENTS[343]

It is important to be selective in choosing the papers to be recycled. Heavily coated printed papers, such as glossy printed pages of magazines, are difficult to break down due to their coatings and dense layers of printed ink applied. The recycling of newspapers through the traditional papermaking process is also discouraged because of the type of ink used in newspaper printing. The printing ink is made up of industrial carbon waste and used engine oil, which will create an unpleasant back scum on the surface of the water once the paper is soaked.[344]

The suitable items for papermaking recycling are envelopes, notepapers, photocopy papers, as well as tissue papers. These papers can easily be broken down and thus

[343] Beata Thackeray, 'Simple papermaking', in id. *Paper: making, decorating, designing* (London: Conran Octopus, 1997), pp. 38-39.
[344] *Ibid.*

making them ideal for pulping in the handmade papermaking process. After the waste papers to be recycled are collected, they are to be torn into small pieces, measuring about 1.5 inch by 1.5 inch, for the next pulping stage.[345]

FIGURE 7-3 AN IDEAL SMALL PAPERMAKING WORKSHOP SET UP IN THE BARCELONA SCHOOL OF ARTS AND CRAFTS

Parts of the workshop: [1] Drying rack, [2] felt, [3] mold, [4] water source, [5] drainage area, [6] press, [7] ventilation, [8] containers, [9] vat, and [10] flat surfaces.[346]

The next important step will be the setting up of a suitable working area, and gathering the required equipment for the papermaking. Professor Josep Asunción from the Barcelona School of Arts and Crafts, in his book, 'The complete book of papermaking', suggested that, "*You don't need a large space or costly equipment to*

[345] Beata Thackeray, 'Simple papermaking', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), pp. 38-39.

[346] Josep Asunción, 'Setting up a small workshop for making paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 51.

make paper; but, keep in mind that the quality of the paper and the amount that you can produce depend on your equipment."[347] There are two essential requirements for setting up a small workshop or studio [SEE FIGURE 7-3] for papermaking: adequate ventilation and a good drainage system. As water is the principle medium used in papermaking, good ventilation and preferably natural ventilation will help in minimizing the build up of humidity. Whereas a good drainage system will avoid complicated plumbing when working with water in the papermaking process. A best setup is to have a huge washtub with a drain underneath. This will make cleaning up easier as well.[348]

FIGURE 7-4 A SMALL PAPERMAKING CORNER[349]

However, if there were limitations, such as funds or floor space, in building a small papermaking workshop, the schools can opt for setting up a small papermaking corner [SEE FIGURE 7-5] with less expensive equipment as an alternative.[350]

[347] Josep Asunción, 'Setting up a small workshop for making paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 51.
[348] *Ibid.*
[349] Josep Asunción, 'Setting up a paper workshop with limited means', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 71.
[350] *Ibid.*

THE PAPERMARKING EQUIPMENT

The most expensive equipment within a papermaking workshop or studio is the beater.[351] In 1680, a Dutchman invented a machine that drastically reduced down the time required to reduce rags into fibers in the pulp production.[352] The Hollander beater, named after its place of invention, came into extensive use in the 1600s in Holland,[353] and soon replaced the time-consuming stamping process with the former stamp beaters [SEE FIGURE 4-5] in the paper mills.[354] Although rags are no longer the main ingredient papermaking, the Holland beaters are still commonly used around the world to this day.[355]

FIGURE 7-5 THE HOLLANDER BEATER

A modern-day steel Hollander beater made by Soteras. It holds a little less than 800 grams of dry pulp, which is just about the right amount for a small papermaking studio.[356]

A Hollander beater is made up of the following components: an oval reservoir with a central partition, a beater, a plate on the bed of the beater, and a top. As the fibers

[351] Vance Studley, 'Holland Beater', in id, *The art and craft of handmade paper* (New York: Van Nostrand Reinhold, 1977), p. 50.
[352] Beata Thackeray, 'Early Mechanization', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), p. 11.
[353] Vance Studley, *op. cit.*
[354] Bernard Toale, 'Traditional European Papermaking', in id., *The art of papermaking* (Worcester, Massachusetts: Davis Publications, 1983), p. 43.
[355] Beata Thackeray, *op. cit.*
[356] Josep Asunción, 'Refining instruments', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 53.

are circulated through the channel of the reservoir, and as they pass through the beater they are softened, beaten, or blended, depending on the pressure applied to the plate on the bed.[357]

FIGURE 7-6 PREPARING THE PULP USING A HOLLANDER BEATER[358]

Despite the convenience of the Hollander beater, it is not easy to acquire one, mainly because of its high cost and low availability in the market.[359] Hence, in many small-

[357] Josep Asunción, 'Refining instruments', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 53.
[358] Josep Asunción, 'Making a sheet of paper step by step', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 76.
[359] Beata Thackeray, 'Blender', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), p. 34.

scale paper productions, electric kitchen blenders or handheld blenders are used instead.[360]

FIGURE 7-7 PREPARING THE PULP USING A KITCHEN BLENDER[361]

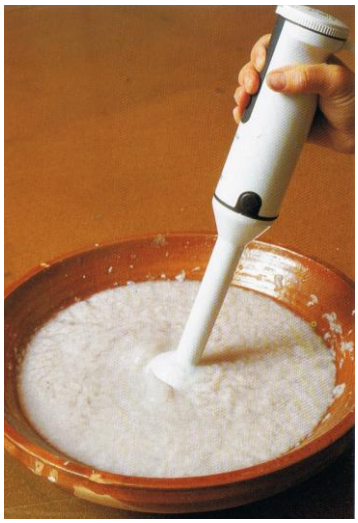


FIGURE 7-8 PREPARING THE PULP USING A HANDHELD BLENDER[362]

[360] Bernard Toale, 'Beating the fibers', in id., *The art of papermaking* (Worcester, Massachusetts: Davis Publications, 1983), pp. 30-31.

[361] Brenna Zedan, 'How to make paper', *Flickr* [website], updated 20 Sep. 2005, <http://www.flickr.com/photos/bzedan/sets/967347/>, accessed 06 Oct. 2008.

[362] Beata Thackeray, '2 Preparing the pulp', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), p. 39.

FIGURE 7-9 THE VATS

These are the most common types of vats used in small papermaking workshops. They can be bought at shop specializing in plastic items.[363]

FIGURE 7-10 PREPARING THE VAT

Once the pulp has been prepared, it is poured into the vat with water to make the sheet. Stirring will help in avoiding lumps and uneven thickness in making one sheet to another.[364]

The vats are used to contain the liquid pulp for papermaking. The vats can be made of wood, stone, or plastics in any shapes that facilitate the water circulation and cleaning. The size of the vat needed depends on the size and the quantity of paper

[363] Josep Asunción, 'Vats', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 59.

[364] Josep Asunción, 'Making a sheet of paper step by step', in id., *The complete book of papermaking* (New York: Lark Books, 2003), pp. 77-78.

to be produced, as well as the space available in the papermaking workshop. An ideal capacity of a vat used in a small papermaking workshop is about 100 liters or 25 gallons, and 60 x 45 x 30 cm in dimension.[365]

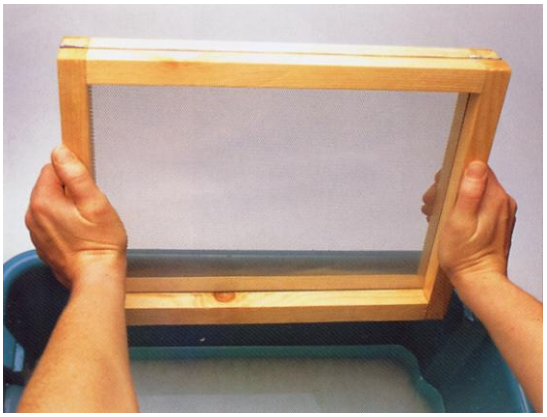


FIGURE 7-11 THE MOLD AND THE DECKLE[366]

The most essential pieces of equipment needed in papermaking are the mold and the deckle. The mold is made up of a fine mesh stretched across a frame, upon which a layer of pulp will be formed on top of the frame, whereas the deckle holds the pulp in place on the mold during the sheet-forming process.[367] To form a sheet of paper, the mold and the deckle are to be submerged together into the vat, and once they reached the bottom of the vat, they are to be lifted out quickly so that a layer of pulp can be formed on top of them. Gentle shakes can be given to spread out the pulp more uniformly to make a more even sheet of paper.[368]

[365] Josep Asunción, 'Vats', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 59.
[366] John Plowman, 'Making a sheet of paper', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 28.
[367] John Plowman, 'Making a mold, deckle and press', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 14.
[368] Josep Asunción, 'Forming the sheet', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 78.

FIGURE 7-12 MAKING LARGE FORMAT WHITE PAPER USED FOR DRAWING OR PAINTING IN FINE ARTS CLASSES[369]

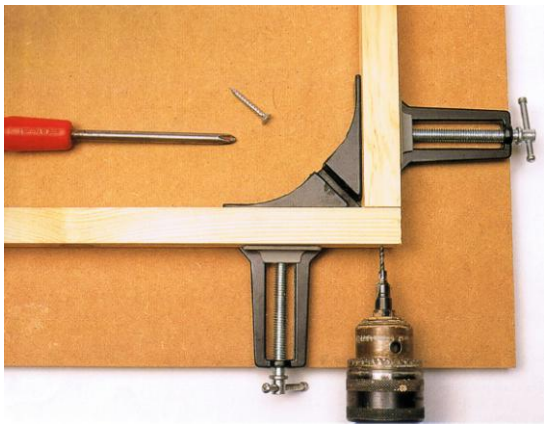
The size of the vat, mold and deckle are dependable on the size of paper to be produced. For large format paper production, the mold must be ribbed to support the large paper, and it would require the hands of two people.[370]

The following is an example on how to make a mold and a deckle that produces an 8 x 10 inches letter-size paper. Materials and equipments required are as followed: four pieces of planed wood (3/4 x 10 inches), four pieces of planed wood (3/4 x 12 inches), 1.5 inches non-corrosive screws, waterproof wood glue, waterproof tape,

[369] Josep Asunción, 'Large Format Paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 146.
[370] *Ibid.*

polyurethane varnish, expanded aluminium mesh (approximately 30 mesh, which means 30 strands of material to an inch)[371], corner clamp, electric drill, screw driver, scissor, staple gun and staples.[372]

TABLE 7-1 HOW TO MAKE A MOLD AND A DECKLE[373]



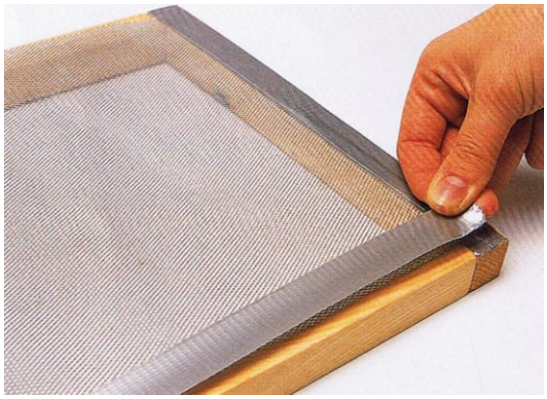
STEP 1

Apply waterproof wood glue to one end of a long length of wood and clamp it at right-angles to a shorter length. After drilling and countersinking a hole, screw the two pieces together to produce a right-angled section. Repeat with the remaining long and short lengths of wood. Use the corner clamp to join the two sections together as before to form the frame. Let the glue dry for twenty-four hours, then apply two coats of varnish to provide a waterproof finish to the wood.

STEP 2

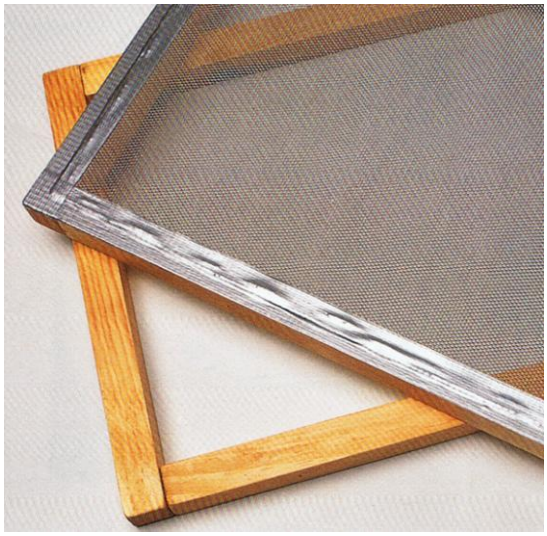
Cut the expanded aluminum mesh so that it is slightly smaller than the outside dimensions of the frame. Staple the middle of one side of the mesh, pull it across the frame, and staple the middle of the opposite side into the frame; repeat on the other two sides. Gradually work your way around the frame stapling the mesh, making sure it is stretched tight across the frame.

[371] Vance Studley, 'The mold and deckle', in id., *The art and craft of handmade paper* (New York: Van Nostrand Reinhold, 1977), p. 44.
[372] John Plowman, 'Making a mold, deckle and press', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), pp. 14-15.
[373] *Ibid.*, pp. 16-17.



STEP 3

Stick waterproof tape along the top to make sure that the sharp edges of the aluminum mesh do not interface with the sheet forming process.



STEP 4

The mold and deckle are now complete, As you can see, the deckle, made the same way as the frame, fits neatly on top of the mold.

FIGURE 7-13 COUCHING

The process of transferring the sheet of paper from the mold to the felt.[374]

Couching is derived from the French verb, 'coucher', which means to lie down.[375] Couching refers to the method of transferring the wet layer of pulp onto a surface, most often on felt, for the subsequent pressing process. In couching, the mold is laid onto the felt facing downward, the mold is then rocked back and forth a couple of times, and thereafter gradually lifted away, leaving the formed sheet behind on the felt. Another layer of felt is then laid over the freshly couched sheet and ready for the next.[376]

[374] John Plowman, 'Making a sheet of paper', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 33.
[375] *Ibid.,* p. 31.
[376] Beata Thackeray, '9 Couching the sheet', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), p. 46.

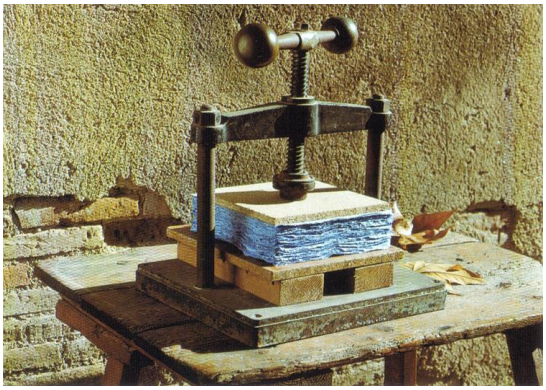


FIGURE 7-14 A SMALL IRON PRESS[377]

This small iron press, which is used in book binding, can also be used to press small sheets.[378]

The next equipment in papermaking is the press. The press is used to serve two functions. Primarily, it is used to remove water from the felt and pulp, changing the wet pulp into paper. Secondly, pressing affects the surface of the final sheet. It gives the paper a smoother finish and removes excessive curling. A press can be used as a restraining device to keep the paper flat while drying.[379] Hence, in some paper mills, a second pressing is applied to smoothen out the sheets after they are dried.[380]

[377] Josep Asunción, 'Presses', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 54.
[378] Bernard Toale, 'The press', in id., *The art of papermaking* (Worcester, Massachusetts: Davis Publications, 1983), pp. 66-67.
[379] *Ibid.*
[380] Josep Asunción, 'Handmade paper and industrial paper', in id., *The complete book of papermaking* (New York: Lark Books, 2003), pp. 74-75.

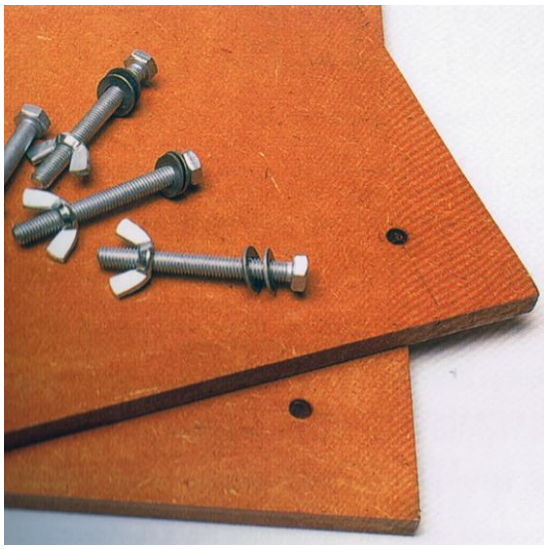
FIGURE 7-15 A MANUFACTURED CONTEMPORARY CAST-IRON PRESS[381]

Although the press is not an essential piece of equipment in papermaking, having one would certainly make the production process much easier. There are of course manufactured presses available in the market, but they are expensive. The following shows how a simple and yet effective press can be made from two composite boards with four screws and four wing nuts.[382]

[381] Josep Asunción, 'Presses', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 55.

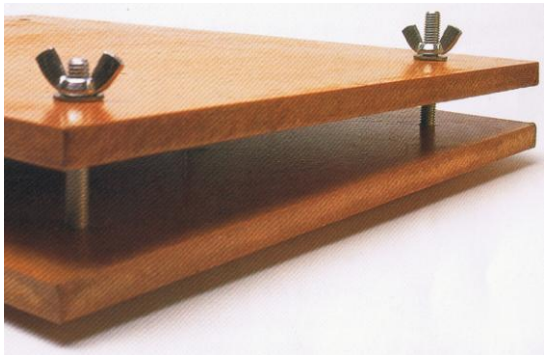
[382] John Plowman, 'Making a mold, deckle and press', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 14.

TABLE 7-2 HOW TO MAKE A SIMPLE PRESS[383,384]



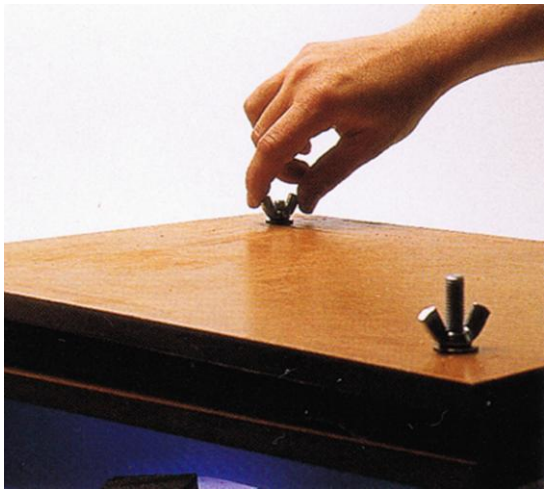
STEP 1

To make the press you need two pieces of composite boards, each measuring ¼ x 12 x 16 inches in dimension. Drill a hole for a bolt in each of the four corners. Coat both boards with varnish provide a waterproof finish.



STEP 2

The press shown is set up and ready to go. To work efficiently, it must have the holes aligned directly above one another.

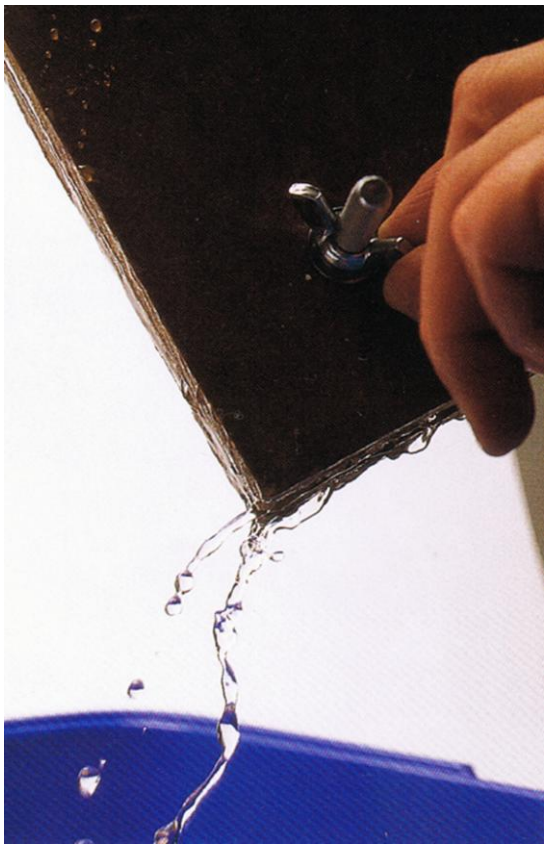


STEP 3

When pile of the freshly couched sheets is ready for pressing, place the pile in between the two boards of the press. With the press positioned over a tray to collect the expelled water. Insert the bolts and start to tighten the wing nuts. Water will then start to be expelled from the side of the press.

383 John Plowman, 'Making a mold, deckle and press', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 17.

384 John Plowman, 'Making a sheet of paper', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 35.



STEP 4

As you increase the pressure, the water will really start to gush from the press. Keep turning the nuts to sustain this pressure to expel most of the water.

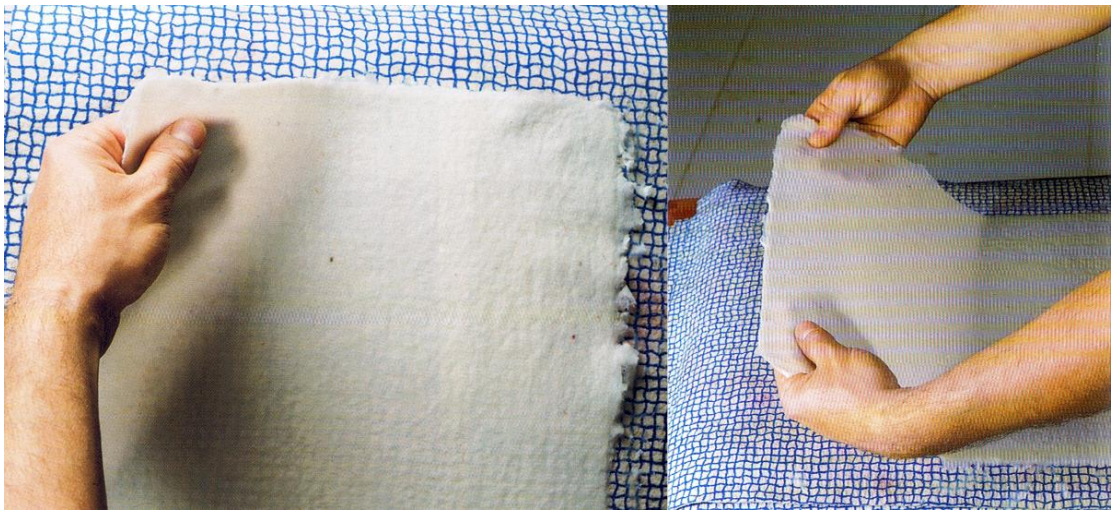


FIGURE 7-16 LAYING

Laying refers to the separating of the paper from the felt.[385]

Once no more water is issued from the press, it means the paper is ready to be removed from the felt for the final drying process. The separating of the paper from the felt, as known as 'laying', is a very delicate operation.[386] As some fibers have a very fine texture, it must be done with gentle care to avoid tearing the newly made sheet.[387] After the sheet is peeled away from the felt, hang the sheet on a clothesline or clothes rack to dry.[388]

[385] Josep Asunción, 'Laying', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 82.
[386] *Ibid.*
[387] Beata Thackeray, '11 Drying the sheet', in id., *Paper: making, decorating, designing* (London: Conran Octopus, 1997), p. 47.
[388] Josep Asunción, 'Drying', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 82.

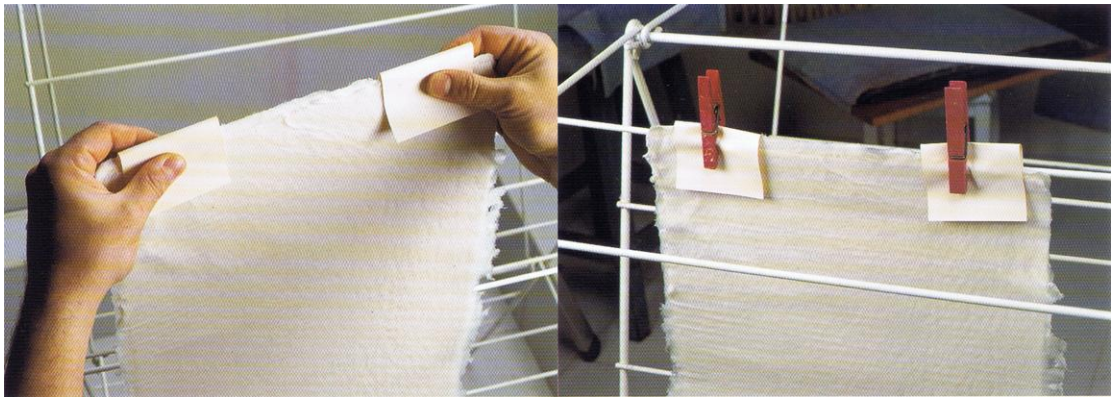


FIGURE 7-17 DRYING

When hanging the sheets out to dry on a clothesline or clothes rack, use a piece of perfectly clean, folded thick paper to keep the clothespins from damaging the newly formed paper.[389]

However, if the paper is not pressed thoroughly, it may be impossible to peel off the paper from the felt without tearing it. In this case, it would be better to allow the paper to be dried on the felt and be separated from the felt later.[390]

FIGURE 7-18 DRYING WITH THE FELT[391]

[389] Josep Asunción, 'Drying', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 82.
[390] Josep Asunción, 'Laying', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 82.
[391] Josep Asunción, 'Drying', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 83.

After drying, many of the paper often become very wrinkled. Thus if desired, the sheets can be straightened by giving them a final dry pressing using either a small press or a household iron.[392]

FIGURE 7-19 DRY PRESSING USING A PRESS

The paper will become nice and smooth after been pressed for two to three days.[393]

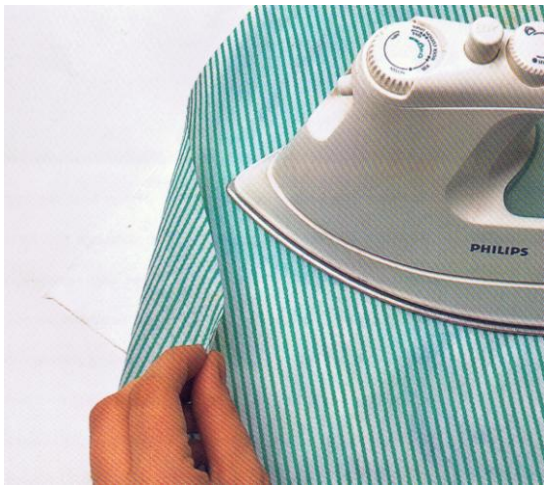


FIGURE 7-20 DRY PRESSING USING AN IRON

Alternatively, the sheets can also be straightened through ironing.[394]

[392] Josep Asunción, 'Dry pressing', in id., *The complete book of papermaking* (New York: Lark Books, 2003), p. 84.
[393] *Ibid.*
[394] John Plowman, 'Making a sheet of paper', in id., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997), p. 36.

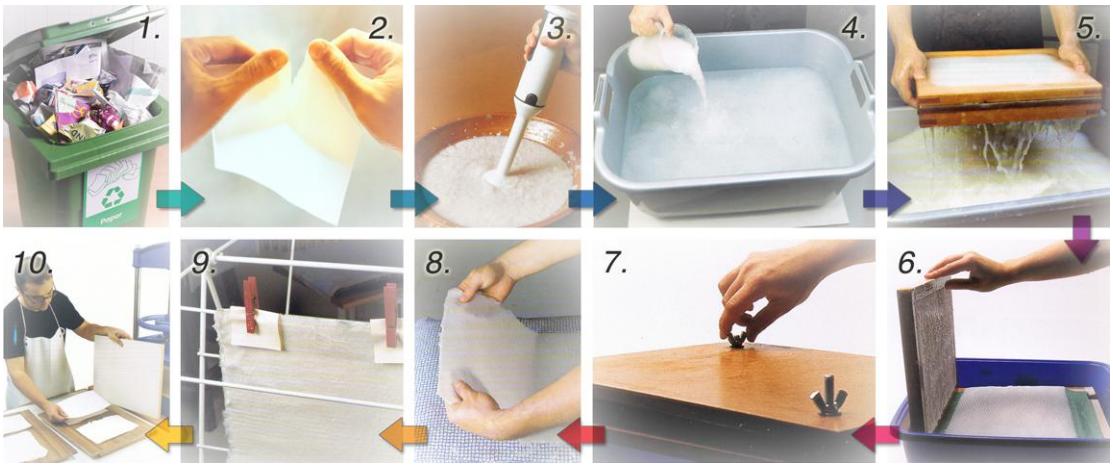


FIGURE 7-21 THE SYSTEM FLOW CHART OF PAPER RECYCLING THROUGH PAPERMAKING BY HAND

A summary of the papermaking process: [1] Collecting and choosing the wastepaper, [2] Shredding the wastepaper, [3] Preparing the pulp, [4] Preparing the vat, [5] Forming the sheet, [6] Couching the sheet, [7] Pressing the sheet, [8] Laying the sheet, [9] Drying the sheet, and [10] Straightening the sheet.

So far, this section has showed how waste paper could be recycled into new paper through the simple traditional papermaking process. It has also shown how a simple papermaking workshop or system can be set up within the school premises. The biggest plus point of this proposed paper recycling system over the existing one in the local schools is that through the papermaking process the students will more likely be able to understand the entire paper recycling process. The students' involvement in the paper recycling process would not only be disposing their used paper into the recycling bins. The students will get to participate in the entire paper recycling process from the initial waste paper collection stage to the final production of new recycled paper.

The huge flexibility in the scale of setup is another huge plus point of this system. Schools with limited means in funds or floor space can opt for a smaller setup that is

less expensive. For instance, equipment like Hollander beater and paper press are entirely optional, and hence can be omitted to save on cost and floor space, if desired. As for schools that desire a better and larger paper production, they can invest into a larger setup with better equipment.

In the next chapter, the test on the feasibility of this new paper recycling system will be discussed.

CHAPTER EIGHT - FEASIBILITY STUDY

In the previous chapter, the concept of the new paper recycling system for local schools has been proposed. Like how Professor Daniel Cuffaro, chairman of the Industrial Design Department in Cleveland Institute of Art, described in his book that, "*Within the process of developing a product from beginning to end, there are three primary stages: planning, development, and production.*"[395]

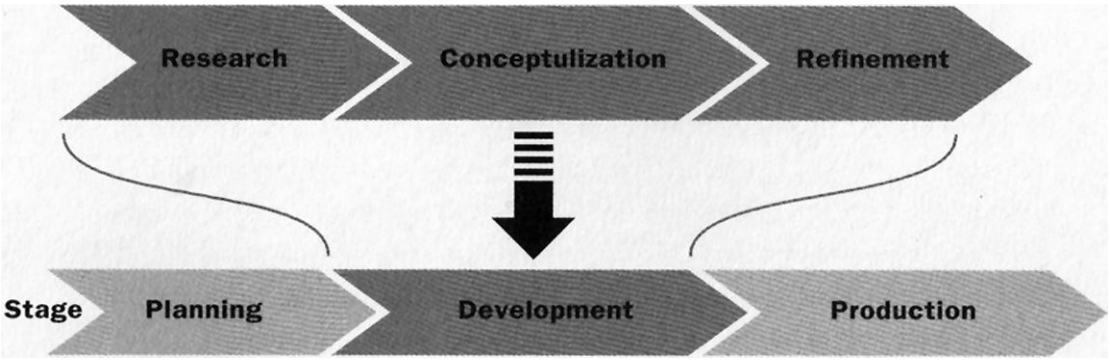


FIGURE 8-1 THE DESIGN PROCESS

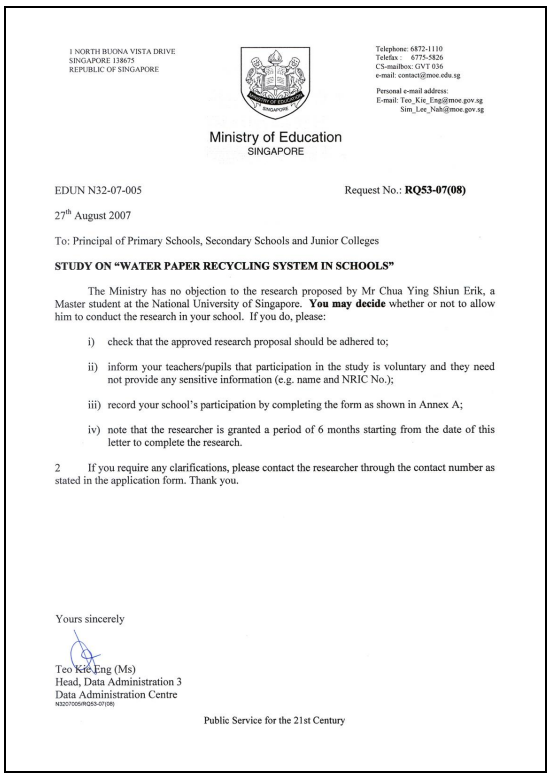
The research, conceptualization, and refinement process are subcomponent of the larger development process.[396]

The initial planning stage typically involves an initiating event, such as the identification of a new need or opportunity of a new product,[397] which has been covered in the earlier part of this thesis. After the planning stage, what follows is the development stage, where the research, conceptualization and refinement process

[395] Daniel F. Cuffaro, 'Macro process', in id., *Process, materials, and measurements: all the details industrial designers need to know but can never find* (Gloucester, Massachusetts: Rockport Publishers, 2006), p. 24.
[396] *Ibid.*
[397] Daniel F. Cuffaro, 'Planning', in id., *Process, materials, and measurements: all the details industrial designers need to know but can never find* (Gloucester, Massachusetts: Rockport Publishers, 2006), p. 24.

make up the subcomponents of the development process.[398] The research process has been discussed in the previous section, and the conceptualization process in the previous chapter. This chapter will cover the refinement process, which is largely focused on the testing of the feasibility of the proposed design for the schools in Singapore.

One of most effective feasibility test would be to conduct a pilot project in one of the local schools, and the first step would be to obtain approval for the design testing from the Ministry of Education. Hence an application letter has been submitted to the Ministry of Education, and it was approved shortly after.



1 NORTH BUONA VISTA DRIVE
SINGAPORE 138675
REPUBLIC OF SINGAPORE

Telephone: 6872-1110
Telefax : 6775-5826
CS-mailbox: GVT 036
e-mail: contact@moe.edu.sg

Personal e-mail address:
E-mail: Teo_Kie_Eng@moe.gov.sg
Sim_Lee_Nah@moe.gov.sg

Ministry of Education
SINGAPORE

EDUN N32-07-005 Request No.: **RQ53-07(08)**

27th August 2007

To: Principal of Primary Schools, Secondary Schools and Junior Colleges

STUDY ON "WATER PAPER RECYCLING SYSTEM IN SCHOOLS"

The Ministry has no objection to the research proposed by Mr Chua Ying Shiun Erik, a Master student at the National University of Singapore. **You may decide** whether or not to allow him to conduct the research in your school. If you do, please:

i) check that the approved research proposal should be adhered to;

ii) inform your teachers/pupils that participation in the study is voluntary and they need not provide any sensitive information (e.g. name and NRIC No.);

iii) record your school's participation by completing the form as shown in Annex A;

iv) note that the researcher is granted a period of 6 months starting from the date of this letter to complete the research.

2 If you require any clarifications, please contact the researcher through the contact number as stated in the application form. Thank you.

Yours sincerely

Teo Kie Eng (Ms)
Head, Data Administration 3
Data Administration Centre

Public Service for the 21st Century

FIGURE 8-2 APPROVAL LETTER FROM THE MINISTRY OF EDUCATION

[SEE APPENDIX C FOR THE FULL SIZE LETTER]

398 Daniel F. Cuffaro, 'Development', in id., *Process, materials, and measurements: all the details industrial designers need to know but can never find* (Gloucester, Massachusetts: Rockport Publishers, 2006), p. 25.

After obtaining the approval from the Ministry of Education, letters were sent out to various primary schools, secondary schools and junior colleges in Singapore to seek for permission and support to conduct the design testing in their school premises, and Woodgrove Secondary School offered their support.

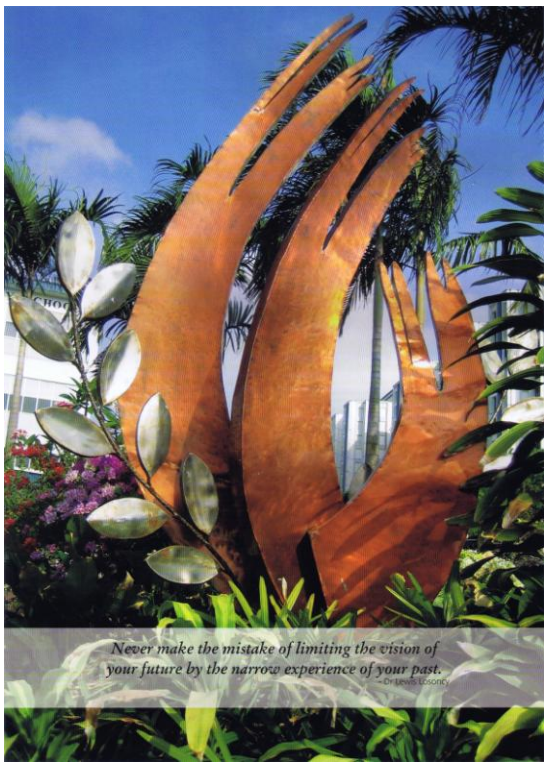


FIGURE 8-3 THE WOODGROVE SPIRIT

Never make the mistake of limiting the vision of your future by the narrow experience of your past.[399]

COLLABORATION WITH WOODGROVE SECONDARY SCHOOL

Woodgrove Secondary School was established in July 2000 under the leadership of their pioneer principal, Mrs. Helena Song. In 2001, the school achieved their first School's Green Audit Award - Hibiscus Award by the Singapore Environment Council, and in 2002, they received their second award, the Orchid Award. Thereafter, the school continued to demonstrate their strong commitment towards environmental educations, and was awarded the most prestigious Sustained Lotus

[399] Woodgrove Secondary School, 'The Woodgrove spirit', in id., *Another book of gifts by Woodgrove Secondary School* (Singapore: Oxford Graphic Printers, 2006), p. 9.

Award twice for 2003-2005 and 2005-2007. In 2007, the school flagged a new principal-ship under Mdm. Sung Mee Har.[400]

FIGURE 8-4 WOODGROVE SECONDARY SCHOOL RECEIVED THE SUSTAINED ACHIEVEMENT AWARD ON 18 APRIL 2008

Principal Mdm. Sung received the award together with 22 Green Activists Club students and teacher-in-charge, Ms. Lim Bin.[401]

After much discussion with Mdm. Sung, the principal, and Mrs. Ong, the vice principal, it was agreed that the pilot project would be conducted with the teachers and students from the Green Activists Club. However, due to the lack of room available for the setting up of a permanent papermaking workshop in the school premises, a temporary setup was done in one of the Food and Nutrition (F&N) laboratories. The laboratory was chosen on account of its close proximity from the

[400] Woodgrove Secondary School, 'History', *Woodgrove Secondary School* [website], <http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=5517>, accessed 06 Oct. 2008.

[401] Woodgrove Secondary School, 'Green audit award presentation & ceremony 2008', *Woodgrove Secondary School* [website], <http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=32933>, accessed 06 Oct. 2008.

'Green Corner', where the waste paper recycling bin is situated, and the availability of water supply within the laboratory.

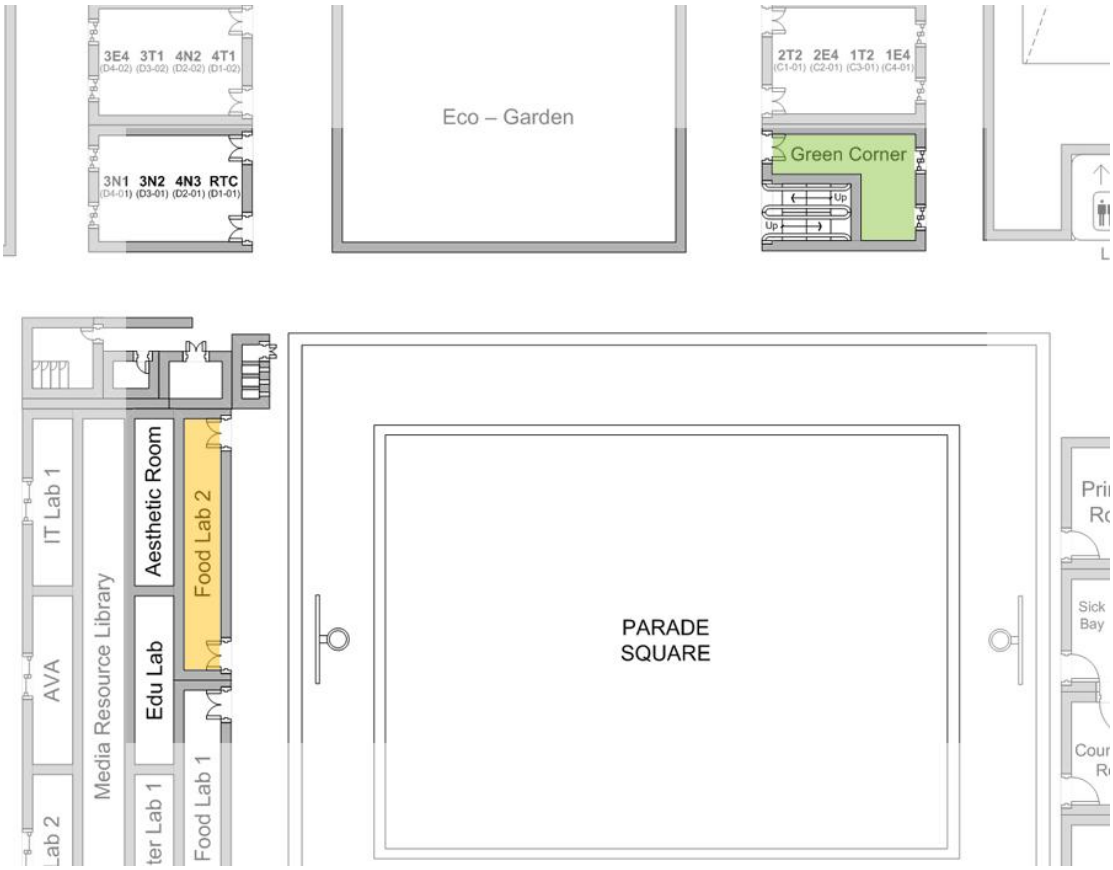


FIGURE 8-5 PILOT PROJECT OF THE PAPER RECYCLING SYSTEM IN WOODGROVE SECONDARY SCHOOL[402]

The recycling bin is situated at the 'Green Corner', and a temporary and trial papermaking workshop was set up in 'Food Lab 2'.

In the pilot project, the students first began by collecting the waste papers that were disposed in the paper recycling bin from the school's 'Green Corner', and thereafter bringing the waste paper to the F&N Lab to be made into new recycled paper.

[402] Woodgrove Secondary School, 'WGS campus map', *Woodgrove Secondary School* [website], <http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=3271>, accessed 15 Oct. 2008.

FIGURE 8-6 A TEMPORARY AND TRIAL PAPERMAKING WORKSHOP SET UP FOR THE PILOT PROJECT

In the pilot project, the teachers and students set up a simple papermaking workshop, using materials and equipments that can be found within the school premises.

FIGURE 8-7 STUDENTS TRYING OUT THE RECYCLING OF PAPER THROUGH PAPERMAKING

The students made coloured paper using food dyes.

All of the students who participated in the pilot project gave the feedback that the papermaking setup and the papermaking process were simple and easy. Many of them gave the feedback that the entire recycling experience had been fun and rewarding. All of them learned and understood how waste paper can be recycled into new sheets of paper. The six participating students, under the supervision of two teachers, were able to produce more than fifty new sheets of recycled paper in less than three hours.

The finished products were shown to Mdm. Sung, the principal, and Mdm. Sung was very pleased with the final outcome. Mdm. Sung also gave several good suggestions on how the paper can be produced as useful resources for the school, such as materials for decorating the bulletin boards, or to make them into greeting cards for the school to send out to their supporters. Ms. Lim Bin, teacher-in-charge of the Green Activists Club, also suggested that the recycled paper could be used as materials for their Clean and Green Week's project displays in the following year.

FIGURE 8-8 WOODGROVE SECONDARY SCHOOL'S PROJECT DISPLAY AT THE CLEAN & GREEN WEEK 2006[403]

Woodgrove Secondary School's Green Activists Club teacher, Ms. Lim Bin, believes that the waste paper can be recycled into materials for the Clean and Green Week's displays in 2009.

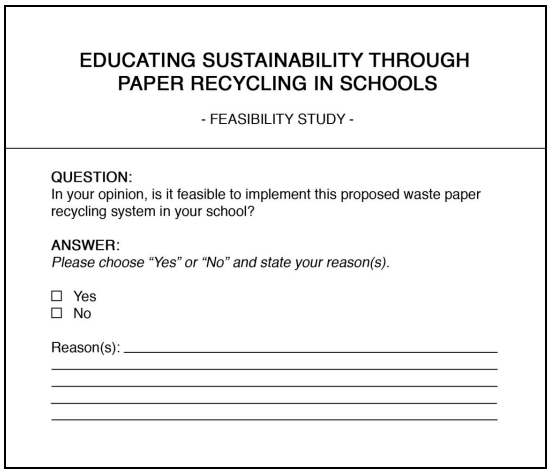
In conversing with Mr. Tan Woon Siong, the Head of Department (HOD) of the Design & Technology (D & T) as well as the Art and Design subject, Mr. Tan also suggested ways in which this new paper recycling process can be integrated with the school's curriculum, such as papermaking classes for the Art and Design subject, as well as getting the upper secondary D & T students to take part in design a papermaking studio for the school.

[403] National Environment Agency, 'Woodgrove Secondary School', *Clean & Green Week* [website], <http://www.acute-soft.com/cgw/photogallery_02A.htm>, accessed 29 Oct. 2008.

As a whole, the new paper recycling system proposal has been well received by the school. The school is now considering on clearing out one of its existing storerooms and converting it into a permanent papermaking workshop in the coming year. Mr. Tan is also discussing with his department staffs on how to possibly integrate the new paper recycling system into the school's curriculum. Ms. Lim Bin also gave a thumbs-up to this waste paper recycling project and has written a feedback saying, "*Thank you for giving Woodgrove Secondary School a chance to work on this paper recycling project. It has been a good learning opportunity for the pupils, Woon Siong and me.*"

ADDITIONAL FEEDBACK

This project proposal was also presented in a D&T Educators Workshop hosted by one of the local tertiary institutions. There were a total forty D&T teaching staff from thirty-four secondary schools who attended this workshop. Due to the research agreement with MOE, the name of the schools and staff involved cannot be published. A survey was conducted after the presentation to obtain feedback on the feasibility of this project from these educational staff.



EDUCATING SUSTAINABILITY THROUGH
PAPER RECYCLING IN SCHOOLS

- FEASIBILITY STUDY -

QUESTION:
In your opinion, is it feasible to implement this proposed waste paper recycling system in your school?

ANSWER:
Please choose "Yes" or "No" and state your reason(s).

☐ Yes
☐ No

Reason(s): _____

FIGURE 8-9 FEASIBILTY STUDY SURVEY QUESTIONNAIRE [SEE APPENDIX D FOR THE FULL SIZE SURVEY QUESTIONNAIRE]

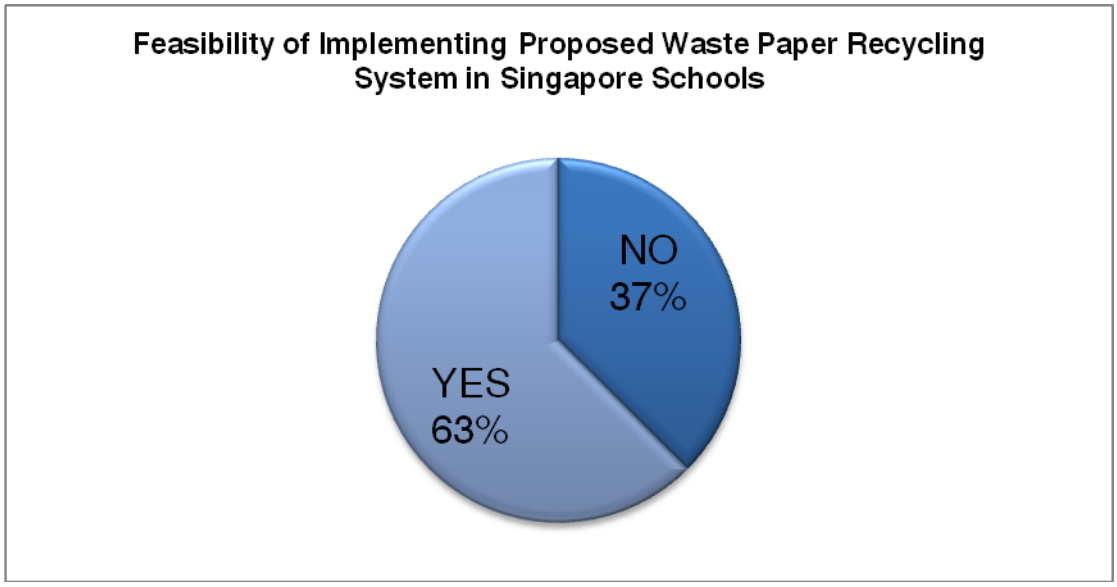


FIGURE 8-10 FEASIBILITY STUDY RESULTS

TABLE 8-1 SAMPLES OF SUVERY FEEDBACK

Survey Respondent	Answer	Reason(s)
A	No	"*I think it is a feasible programme. However, my school is already involved in many environmental education programmes. I'm not sure if we have sufficient time and staff to take up this programme.*"
B	No	"*My main concern is the overheads. If there are a lot of people, space, electricity and water supply required, then I don't think this programme will work.*"
C	No	"*There seems to be a lot of manpower required to implement this programme . . . we have a shortage of staff now.*"
D	No	"*At the moment, I don't think there is any free space within our school to build the papermaking workshop.*"
E	No	"*Interesting program . . . but not sure if we can get the funding to run this program.*"
F	Yes	"*Good idea! At least, it is more meaning to make new paper than to dump the used paper into the recycling bins.*"
G	Yes	"*We can get more students and staff involved in the school's recycling programme.*"

H	Yes	"*It is always good to give the students a more hands-on experience . . . The students can see a bigger and cleaner picture of paper recycling. And also to sustainability.*
I	Yes	"*Good proposal! It is very much in line with the ongoing green movement.*"
J	Yes	"*A wonderful way to integrate environmental education into the school curriculum.*"

Out of the forty participants, twenty-five of them said 'Yes' to the feasibility of implementing this proposed paper recycling system in their school. As for the remaining fifteen participants, many of them explained that they were not negative towards the proposal. They indicated 'No' because they were unsure if their school would take up this project due to lack of financial and manpower resources. Nonetheless, they agreed that it is a good way to educate the students about recycling and sustainability.

CONCLUSION

From this research study, I have understood the problems of over-consumption of paper and the need for sustainability. I have also learnt that education is one of the most effective means to promote sustainability. With a good recycling program established in schools, it would not only help to minimize refuse disposal, but it would also help to educate students with a better understanding of environmental protection, conservation and sustainability. In this study, I have also explored the feasibility of setting up a paper recycling system in Singapore schools that could be incorporated as an additional educational resource to the schools.

At the beginning of this research, I investigated the historical development of the human society from its early agrarian society based on the domestication of plants and animals to modern-day industrialized society. The development of the industrial system since the Industrial Revolution has brought about the mass production of goods, which in turn has also resulted in the perpetuation of our 'throwaway society' of today and the escalation of waste disposal.

From the earlier study, I learnt that there is definitely a need for sustainability. Through my research I was led to understand how education is one of the most effective means to promote the idea. I also learnt that the process of recycling is a good method to educate the masses on the practices of sustainability while at the same time minimizes waste disposal and generates new useful resources.

Subsequently, I also looked into the invention of paper, as well as how the rise of civilization awakened the desire for learning. As a result, this motivated men to

develop more efficient ways to spread knowledge and information through writing and reading. However, with inventions such as the printing press and the photocopying machine, our usage of paper has also escalated enormously over the past century.

In addition, I reviewed the myth of the paperless society; the grand claims that computers and the Internet would one day bring about a paperless society. The documents show that on the contrary, paper consumption has risen since 1970s. People still prefer to print their documents on paper to read, instead of reading them off from the computer screen. As such, we find ourselves in the dilemma between our preference towards paper and the issue of paper consumption skyrocketing worldwide.

In the latter half of my research, I looked at the context of Singapore, where I learned how the government seek to model Singapore as a green city – a city with a comprehensive and sophisticated sustainable environmental infrastructure. In 1992, the Singapore government presented the 'Singapore Green Plan', which looked at all areas of environmental concerns in Singapore, and one of the major environmental concerns addressed was to reduce waste disposal. In the 'Singapore Green Plan', the government of Singapore emphasized the importance of recycling programs as well as environment education in national schools.

From the national schools' environmental program, I was introduced to the School Recycling Outreach Program. This program was targeted at local primary and secondary schools, together with the junior colleges to get students and staff involved in reaching out to their neighboring residents to promote better environmental awareness and practices in waste minimization and recycling. From

this program, I found the opportunity to explore how waste paper in schools can be recycled into useful materials and resources for the various activities in the program.

This led me into doing a feasibility study of establishing a paper recycling system for the schools through the traditional papermaking process. Through this process, students would be able to attain a better understanding of the entire paper recycling process from its initial waste paper collection stage to the final production of recycled paper.

Finally, I set up a pilot project in collaboration with one of the local secondary schools, Woodgrove Secondary School, to test the feasibility of the paper recycling system proposal. As a result, it was found to be a good and feasible proposal. All of the participated staff and students were well-please with the final outcome. The principal and staff are keen to explore ways to integrate this paper recycling process into the school's curriculum. The proposal was also presented in a D&T Educators Workshop. Out of the forty surveyed audience, twenty-five of them are in favour of the feasibility of implementing this project in the local institutions.

On the whole, I have personally benefited greatly from this entire research. I have gained much valuable knowledge through the study of the various subjects in this research. I am also thankful to the experience gathered from working with Woodgrove Secondary School.

As a final conclusion, it is clear that the process of industrialization and modernization has led to the build up of waste. There is a need to understand the mounting problems. There is also the need to practice sustainability in order to keep the problem within control. People need to be educated on the issue and one of the

most effective means is through the school education program. The paper recycling pilot project that was undertaken proved that it is feasible to incorporate recycling and therefore sustainability education in schools.

BIBLIOGRAPHY

PUBLISHED BOOKS AND ARTICLES

ASUNCIÓN, J., *The complete book of papermaking* (New York: Lark Books, 2003).

BAARACLOUGH, S., *The recycling centre* (London: Franklin Watts, 2006).

BARON, N. S., *Alphabet to email: how written English evolved and where it's heading* (London; New York: Routledge, 2000).

BATCHELOR, R., *Henry Ford, mass production, Modernism and design* (Manchester; New York: Manchester University Press, 1994).

BAUD, I., POST, J. and FUREDY, C. (eds.) *Solid waste management and recycling: actors, partnerships, and policies in Hyderabad, India and Nairobi, Kenya* (Dordrecht: Kluwer Academic Publishers, 2004).

BLOOM, J. M., *Paper before print: the history and impact of paper in the Islamic world* (New Haven; London: Yale University Press, 2001).

BORGMAN, C. L., *From Gutenberg to the global information infrastructure: access to information in the network world* (Cambridge, Massachusetts: MIT Press, 2000).

BRIFFETT, C. and SIM, L. L. (eds.), *Environmental issues in development and conservation* (Singapore: SNP Publishers, 1993).

BRIGGS, A. (ed.), *Who's who in the twentieth century* (Oxford: Oxford University Press, 1999).

CADY, B. and NAUDET, J., *Icons of the twentieth century: 200 men and women who have made a difference* (New York: The Overlook Press, 1998).

CHEREMISINOFF, N. P., *Handbook of solid waste management and waste minimization technologies* (Amsterdam; London: Butterworth-Heinemann, 2003).

CHUA, L. H., *The Singapore Green Plan 2012: beyond clean and green towards environmental sustainability* (Singapore: Ministry of the Environment, 2002).

COOPER, R. C., *War on waste: how to make millions from trash* (Singapore: Vocational Service Committee of the Rotary Club of Singapore, 1991).

COSNER, S., *Paper through the ages* (Minneapolis, Minnesota: Carolrhoda Books, 1984).

COUZINS-SCOTT, E., *Papermaking: the craft of creative paperwork in 25 innovative projects* (London: Southwater, 2002).

CROMPTON, S. W., *The printing press* (Philadelphia, Pennsylvania: Chelsea House Publishers, 2004).

CUFFARO, D. F. (ed.), *Process, materials, and measurements: all the details industrial designers need to know but can never find* (Gloucester, Massachusetts: Rockport Publishers, 2006).

CUNNINGHAM. W. P., et al. (eds.), *Environmental Encyclopedia* (2nd edn., Detroit: Gale Research, 1998).

DAWSON, S., *The art and craft of papermaking* (London: Quarto, 1992; repr. Asheville, North Carolina: Lark Books, 1996).

DIAMOND, J., 'The worst mistake in the history of the human race', *Discover Magazine*, May 1987.

DINEEN, J., *Hunting, harvesting and home* (Surrey: Dragon's World, 1995).

DORAI, F. (ed.), *Insight guide: Singapore* (11th edn., Singapore: Apa Publication GmbH & Co.; Verlag KG, 2004).

DORION, C., *Waste disposal* (London: Franklin Watts, 2007).

DRESNER, S., *The principles of sustainability* (London; Sterling, Virginia: Earthscan Publications, 2002).

EXPLORER PUBLISHING, *Singapore: The complete residents' guide* (Dubai: Explorer Publishing and Distribution, 2007).

FLOWER, R., *Raffles: the story of Singapore* (Singapore: Eastern Universities Press, 1984).

FOO, S. L. (ed.), *The Singapore Green Plan 2012* (2006 edn., Singapore: Ministry of the Environment and Water Resources, 2006).

FRIEDMAN, L. S. (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007), p. 74.

GEORGE, T. J. S., *Lee Kuan Yew's Singapore* (2nd edn., Singapore: Eastern Universities Press, 1984).

GILBERT, R. (ed.), *Studying society and environment: a guide for teachers* (3rd edn., South Melbourne, Victoria: Thomson Learning Nelson, 2004).

GILPIN, D. *Food and clothing* (New York: Facts On File, 2004).

GORDON, D. R., *Rochester Institute of Technology: Industrial Development and Educational Innovation in an American City, 1829-2006* (Rochester, New York: Cary Graphic Arts Press, 2007).

HALL, E. J., *Recycling* (Detroit, Michigan: KidHaven Press, 2005).

HARLOW, R. and MORGAN, S., *Garbage and recycling* (2nd edn., Boston, Massachusetts: Kingfisher, 2001).

HAVEN, K. F., *100 greatest science inventions of all time* (Westport, Connecticut: Libraries Unlimited, 2006).

HEINRICHS, A., *The printing press* (New York: Franklin Watts, 2005).

HERRING, M. Y., *Fool's gold: why the Internet is no substitute for a library* (Jefferson, North Carolina: McFarland & Company, 2007).

HOUNSHELL, D. A., *From the American system to mass production 1800-1932: the development of manufactured technology in the United States* (Baltimore: Johns Hopkins University Press, 1984).

HUNTER, D., *Papermaking: the history and technique of an ancient craft* (2nd edn., New York: Dover Publications, 1978).

KAPR, A., *Johann Gutenberg: the man and his invention*, trans. Douglas Martin (3rd edn., Aldershot, Hants; Brookfield, Vermont: Scolar Press, 1996).

KERN, M. E., *The complete book of handcrafted paper* (New York: Coward, McCann & Geoghegan, 1980).

KOELSCH, F., *The infomedia revolution: how it is changing our world and your life* (Toronto: McGraw-Hill Ryerson, 1995).

KOH, A. and LEONG, S., *Singapore chic: hotels, restaurants, shops,spas, resorts, galleries, bars* (Singapore: Archipelago Press, 2006).

KRENSKY, S., *Breaking into print: before and after the invention of the printing press* (Boston: Little, Brown & Co., 1996).

KWA, G. C., HENG, D. and TAN, T. Y., *Singapore: a 700-year history from early emporium to world city* (Singapore: Oxford Graphic Printers Private Limited, 2009).

LAIDLAW, J. A., *Singapore* (London: Dorling Kindersley Limited, 2000).

LEE, S., *The throwaway society* (New York: Franklin Watts, 1990).

LIBRARY OF CONGRESS, *Papermaking: art and craft; an account derived from the exhibition presented in the Library of Congress, Washington, D.C., and opened on April 21, 1968* (Washington, D.C.: Library of Congress, 1968).

LONG, C. J., *The agriculture revolution* (San Diego, California: Lucent Books, 2004).

LUND, H. F., (ed.), *The McGraw-Hill recycling handbook* (2nd edn., New York: McGraw-Hill, 2001).

MCDONOUGH, W. and BRAUNGART, M., *Cradle to cradle: remaking the way we make thing* (New York: North Point Press, 2002).

MCTAVISH, D., *Famous Inventors* (Hove, East Sussex: Wayland, 1993).

MILLER, R. J., (ed.), *Perspectives on Science and Christian Faith*, 54/2 (2002).

MILLIGAN, A., *Singapore - Culture Smart!: a quick guide to customs and etiquette* (London: Kuperard, 2006).

MINISTRY OF THE ENVIRONMENT, *The Singapore Green Plan: Towards a model green city* (Singapore: SNP Publishers, 1992).

MOIZ, A., *The Singapore Green Plan – Action Programmes* (Singapore: Times Editions, 1993).

MULLINS, L., *Inventing the printing press* (New York: Crabtree Publishing, 2007).

OOI, G. L., *Sustainability and cities: concept and assessment* (Singapore: Institute of Policy Studies; Hackensack, New Jersey: World Scientific Publishing Co., 2005).

OSTOPOWICH, M., *Waste: refuse, misuse, and reuse* (New York: Weigl Educational Publishers, 2004).

OWEN, D., *Copies in seconds: how a lone inventor and an unknown company created the biggest communications breakthrough since Gutenberg: Chester Carlson and the birth of the Xerox machine* (New York: Simon & Schuster, 2004).

PAEHLKE, R. (ed.), *Conservation and environmentalism: an encyclopedia* (New York: Garland Publishing, 1995).

PARKINSON, R. and QUIRKE, S., *Papyrus* (Austin, Texas: University of Texas Press, 1995).

PAULAPURO, H. (ed.), *Papermaking Part 1, Stock preparation and wet end* (Helsinki: Fapet Oy; Atlanta, Georgia: TAPPI Press, 2000).

PHILLIPS, E. M. and PUGH, D. S., *How to get a Ph.D: a handbook for students and their supervisors* (2nd edn., Buckingham; Philadelphia: Open University Press, 1994).

PLOWMAN, J., *The craft of handmade paper: a practical guide to papermaking techniques* (London: Apple Press, 1997).

POLLARD, M. *Johann Gutenberg: the story of the invention of movable type and how printing led to a knowledge explosion* (Hertfordshire: Exley Publications, 1992).

RAMCHARAN, R., *Forging a Singaporean statehood, 1965-1995: the contribution of Japan* (London: Kluwer Law International, 2002).

ROGERS, H. *Gone tomorrow: the hidden life of garbage* (New York: New Press, 2005).

ROSS, A. J., *Careers in desktop publishing* (New York: Rosen Publishing, 2000).

ROYSTON, A., *Recycling* (Hove, East Sussex: Wayland Publishers, 1998).

SAKOLSKY, J. (ed.), *Critical perspectives on the Industrial Revolution* (New York: The Rosen Publishing Group, 2005).

SCHOLDERER, V., *Johann Gutenberg: the inventor of printing* (London: British Museum, 1970).

SELLEN, A. J. and HARPER, R. H. R., *The myth of the paperless office* (Cambridge, Massachusetts: MIT Press, 2002).

SHEEHAN, S., *Portrait of Singapore* (London: New Holland Publishers, 2004).

SHEPP, A. STURGE, J. M. and WALWORTH, V. (eds.), *Imaging processes and materials* (8th edn., New York : Van Nostrand Reinhold, 1989).

SHIYOMI, M. and KOIZUMI, H. (eds.), *Structure and function in agroecosystem design and management* (Boca Raton, Florida: CRC Press, 2000).

SMIL, V., *Creating the Twentieth Century* (Oxford; New York: Oxford University Press, 2005).

STALCUP, B. (ed.), *The industrial revolution* (San Diego, California: Greenhaven Press, 2002).

STEFFENS, B., *Printing press: ideas into type* (San Diego, California: Lucent Book, 1990).

STEWART, G. B., *The Renaissance* (Detroit, Michigan: Blackbirch Press, 2006).

STUDLEY, V., *The art and craft of handmade paper* (New York: Van Nostrand Reinhold, 1977).

TAMES, R., *The printing press: a breakthrough in communication* (Oxford: Heinemann Library, 2000).

TARLING, N., (ed.), *The Cambridge history of Southeast Asia* (Vol. 2, Cambridge; New York: Cambridge University Press, 1992).

TAY, S., *Over Singapore* (Singapore: Archipelago Press, 1993).

THACKERAY, B., *Paper: making, decorating, designing* (London: Conran Octopus, 1997).

THINK GREEN, *Recycling* (Irvine, California: Saddleback Education Publishing, 2009).

TIME/CBS NEWS (ed.), *People of the Century* (New York: Simon & Schuster, 1999).

THOMPSON, C. G., *Recycled papers: the essential guide* (Cambridge, Massachusetts: MIT Press, 1992).

TOALE, B., *The art of papermaking* (Worcester, Massachusetts: Davis Publications, 1983).

TURNBULL, C. M., *A history of Singapore 1819-1988* (2nd edn., Singapore: Oxford University Press, 1989).

UNITED NATIONS POPULATION FUND, *State of World Population 2007: Unleashing the Potential of Urban Growth* (New York: United Nations Population Fund, 2007).

UNIVERSITY OF NEW SOUTH WALES, *Education for sustainability* (Sydney: University of New South Wales Publishing and Printing Services, 1999).

UTTERBACK, J. M., *Mastering the dynamics of innovation: how companies can seize opportunities in the face of technological change* (Boston, Massachusetts: Harvard Business School Press, 1994).

VAN DER RYN, S. and COWAN, S., *Ecological Design* (10th Anniversary edn., Washington, D.C.: Island Press, 2007).

WAGNER, V. (ed.), *Recycling* (Farmington Hills, Michigan: Greenhaven Press, 2009).

WALKER, K., *Paper* (South Yarra, Victoria: Macmillan Education Australia, 2009).

WALKER, K., *Recycle, reduce, reuse, rethink* (South Yarra, Victoria: Macmillan Education, 2007).

WARD, G., *Publishing in the digital age* (London: Bowerdean, 1998).

WHEELER, K. A., and BIJUR, A. P. (eds.), *Education for a sustainable future: a paradigm for hope for the 21st century* (New York: Kluwer Academic/Plenum Publishers, 2000).

WINDELSPECHT, M., *Groundbreaking scientific experiments, inventions, and discoveries of the 19th century* (Westport, Connecticut: Greenwood Press, 2003).

WILLIAM, D. O., New Zealand War History Branch, *Episodes & Studies Volume 1* (Wellington: Historical Publication Branch, 1948).

WOODGROVE SECONDARY SCHOOL, *Another book of gifts by Woodgrove Secondary School* (Singapore: Oxford Graphic Printers, 2006).

WOODS, M. and WOODS, M. B., *Ancient agriculture: from foraging and farming* (Minneapolis, Minnesota: Lerner Publications, 2000).

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, *Our common future* (Oxford: Oxford University Press, 1987).

YOUNG, M. (ed.), *Garbage and recycling* (Farmington Hills, Michigan: Greenhaven Press, 2007).

ZAIRI, M. *Effective benchmarking: learning from the best* (London: Chapman & Hall, 1996).

INTERNET (WORLD WIDE WEB) SITE

BOWMAN, A. K., 'Egypt, ancient', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/180468/ancient-Egypt/22283/Introduction-to-ancient-Egyptian-civilization>, accessed 18 Jan. 2008.

BRITISH BROADCASTING CORPORATION, 'The Neolithic Revolution - How farming changed the world', *British Broadcasting Corporation (BBC) – h2g2* [website], published online 05 Mar. 2004, <http://www.bbc.co.uk/dna/h2g2/A2054675>, accessed 16 Jan. 2008.

CHAYEN, S., ‘Sustainable development in Judaism’, *Israel Ministry of Foreign Affairs* [website], published online 10 Aug. 2002, <http://www.mfa.gov.il/MFA/MFAArchive/2000_2009/2002/8/Sustainable%20Development%20in%20Judaism>, accessed 13 Feb. 2008.

DANZER GROUP, ‘The history of sustainability’, *Danzer Group* [website], <http://www.danzergroup.com/History-of-Sustainability.1601.0.html#>, accessed 20 Feb. 2008.

DE CHÂTEL, F., ‘The island paradise built on a garbage dump’, *Cable News Network* [website], published online 26. Jul. 2007, <http://edition.cnn.com/2007/TECH/07/26/ji.semakaulandfill/>, accessed 05 Sep. 2008.

EARLY OFFICE MUSEUM, ‘Typewriters’, *Early Office Museum* [website], <http://www.officemuseum.com/typewriters.htm>, accessed 21 Apr. 2008.

ENCYCLOPEDIA BRITANNICA, INC., ‘United Nations Conference on Environment and Development’, *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/616390/United-Nations-Conference-on-Environment-and-Development>, accessed 11 Feb. 2008.

ENCYCLOPEDIA BRITANNICA, INC., ‘Printing (publishing)’, *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/477017/printing>, accessed 16 Apr. 2008.

ENCYCLOPEDIA BRITANNICA, INC., 'Offset printing', *Britannica Online Encyclopedia 2008*, <http://www.britannica.com/EBchecked/topic/425722/offset-printing>, accessed 18 Apr. 2008.

ERLANGER, S., 'As farmers and fields rest, a land grows restless', *The New York Times* [website], published online 08 Oct. 2007, <http://www.nytimes.com/2007/10/08/world/middleeast/08shmita.html>, accessed 14. Feb. 2008.

ENTERPRISE IRELAND, 'Figure 1. Hierarchy of waste management', *Envirocentre.ie* [website], updated 25 Mar. 2008, <http://www.envirocentre.ie/includes/images/Waste%20Management%20hierarchy3.jpg>, accessed 26 Mar. 2008.

FINDAWAY WORLD, 'What is Playaway', *Playaway* [website], updated 01 Aug. 2006, <http://store.playawaydigital.com/How-to-Play/Getting-Started>, accessed 25 Apr. 2008.

GROBER, U., 'Der Erfinder der Nachhaltigkeit [The inventor of sustainability]', *Die Ziet*, 48 (1992), <http://www.zeit.de/1999/48/Der_Erfinder_der_Nachhaltigkeit>, accessed 19 Feb. 2008.

HALLMAN, D. G., 'Report on the World Summit on Sustainable Development (WSSD)', *World Council of Church* [website], published online 04 Sep. 2002, <http://www.oikoumene.org/?id=2538>, accessed 21 Feb. 2008.

INDUSTRIAL DESIGNERS SOCIETY OF AMERICA, 'Xerox 914 Copier: 1959', *Industrial Designers Society of America* [website], <http://new.idsa.org/webmodules/articles/anmviewer.asp?a=272&z=62>, accessed 21 Apr. 2008.

INDUSTRIAL DESIGN SOCIETY OF AMERICA, 'Designing to protect our planet', *Industrial Design Society of America Ecodesign* [website], <http://www.idsa.org/whatsnew/sections/ecosection/index.html>, accessed 29 Sep. 2008.

LOH, A. T. 'Singapore National 3R Strategy', *3R Workshop on Effective Waste Management and Resource Use Efficiency in East and Southeast Asia - Asian Development Bank* [website], published online 15 Feb. 2007, <http://www.adb.org/Documents/Events/2007/Effective-Waste-Management/Loh-Ah-Tuan-presentation.pdf>, accessed 03 Sep 2008.

MINISTRY OF INFORMATION, COMMUNICATIONS AND THE ARTS, 'Sentosa', *Singapore Infomap* [website], <http://www.sg/explore/gallery_sentosa.htm>, accessed 20 August 2008.

MINISTRY OF THE ENVIRONMENT AND WATER RESOURCES, 'Key Environmental Statistics 2008', *Ministry of the Environment and Water Resources* [website], updated 04 Jul. 2008, <http://app.mewr.gov.sg/data/ImgUpd/KES2008.pdf>, accessed 04 Jul. 2008.

MINISTRY OF THE ENVIRONMENT AND WATER RESOURCES, 'Sustainable Singapore', *Ministry of the Environment and Water Resources* [website], published

online Apr. 2005, <http://app.mewr.gov.sg/web/Contents/ContentsSSS.aspx?ContId=1034>, accessed 29 Aug. 2008.

MINISTRY OF THE ENVIRONMENT AND WATER RESOURCES, 'Three-yearly review of Singapore Green Plan 2012', *Ministry of the Environment and Water Resources* [website], published online Apr. 2005, <http://app.mewr.gov.sg/web/Contents/Contents.aspx?Yr=2005&ContId=624>, accessed 12 Sep. 2008.

MOHD. AZIZ, N., 'Singapore students aware of environmental issues', *Channel NewsAsia* [website], published online 14 Nov. 2006, <http://www.channelnewsasia.com/stories/singaporelocalnews/view/241237/1/.html>, accessed 16 Jul. 2008.

NATIONAL ENVIRONMENT AGENCY, 'Awareness of environment issues among students yet to be translated into action', *National Environment Agency* [website], published online 14 Nov. 2006, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2799>, accessed 16 Jul. 2008.

NATIONAL ENVIRONMENT AGENCY, 'Recycling programme', *National Environment Agency* [website], updated 08 May 2008, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2306>, accessed 08 Aug. 2008.

NATIONAL ENVIRONMENT AGENCY, 'Recycling outreach programme 2008', *National Environment Agency* [website], updated 08 May 2008,

<www.nea.gov.sg/cms/3ppd/recycling_cip/Recycling%20Outreach%20Programme%202008.ppt>, accessed 08 Aug. 2008.

NATIONAL ENVIRONMENT AGENCY, 'School recycling outreach programme', *National Environment Agency* [website], updated 08 May 2008, <http://app.nea.gov.sg/cms/htdocs/article.asp?pid=2678>, accessed 08 Aug. 2008.

NATIONAL ENVIRONMENT AGENCY, 'School recycling outreach programme pamphlet', *National Environment Agency* [website], updated 08 May 2008, <http://www.nea.gov.sg/cms/3ppd/recycling_cip/rop%20pamphlet%202007.pdf>, accessed 08 Aug. 2008.

NATIONAL ENVIRONMENT AGENCY, 'NRP brochure', *National Environment Agency* [website], published online 20 Sep. 2006, <http://www.nea.gov.sg/cms/rcd/NRP_brochure.pdf>, accessed 22 Aug. 2008.

NATIONAL ENVIRONMENT AGENCY, 'Woodgrove Secondary School', *Clean & Green Week* [website], <http://www.acute-soft.com/cgw/photogallery_02A.htm>, accessed 29 Oct. 2008.

OTTO, B. K., 'The essentials of sustainability and sustainable design', *Design Council* [website], published online 14. Nov. 2006, <http://www.designcouncil.org.uk/en/About-Design/Business-Essentials/Sustainability/>, accessed 29 Sep. 2008.

ST. OLAF COLLEGE, ‘Gro Harlem Brundtland’, *The 16th annual Nobel Peace Prize Forum* [website], <http://www.stolaf.edu/nppf/2004/media/brundtland-hi.jpg>, accessed 03 Mar. 2008.

STANMEYER, J., ‘Almost eclipsing the skyscrapers in the background, brilliant lights illuminate thousands of cargo containers in this port in Singapore's harbor. Singapore has one of the largest and busiest ports in the world.’, *National Geographic Society* [website], published online 01 Nov. 2007, <http://ngm.typepad.com/our_shot/november-1-2007.html> , accessed 27 Aug. 2008.

TATA STEEL UK LIMITED, ‘Three dimensions’, *Colorcoat-Online* [website], <http://www.colorcoat-online.com/file_source/StaticFiles/Colorcoat%20Online/Images/three_dimensions_800.jpg>, accessed 12 Mar. 2008.

THULAJA, N. R., ‘Clean and Green Week’, *National Library Board* [website], published online 09 Jan. 2004, <http://infopedia.nl.sg/articles/SIP_395_2005-01-17.html>, accessed 18 Jul. 2008.

THE ECONOMIST NEWSPAPER LIMITED, ‘Hunter-gatherers: noble or savage?’, *The Economist* [website], published online 19 Dec. 2007, <http://www.economist.com/displaystory.cfm?story_id=10278703>, accessed 23 Jan. 2008.

THE GREAT IDEA FINDER, ‘Xerography history – Invention of xerography’, *The Great Idea Finder* [website], updated Feb. 2005,

<http://www.ideafinder.com/history/inventions/xerography.htm>, accessed 23 Apr. 2008.

TIME INC., 'Shmita: 5712', *Time Magazine* [website], published online 10 Oct. 1952, <http://www.time.com/time/magazine/article/0,9171,817136,00.html?iid=chix-sphere>, accessed 14 Feb. 2008.

UNITED NATIONS, 'World population to increase by 2.6 billion over next 45 years, with all growth occurring in less developed regions', *United Nations* [website], published online 24 Feb. 2005, <http://www.un.org/News/Press/docs/2005/pop918.doc.htm>, accessed 07 Feb. 2008.

UNITED NATIONS DEPARTMENT OF PUBLIC INFORMATION PHOTO LIBRARY, 'Johannesburg Summit: Photos - Press Conference: Healthy Environments for Children Initiative 01 September 2002', *United Nations: Johannesburg Summit 2002* [website], updated 23 Mar. 2003, <http://www.un.org/events/wssd/photos/0238.jpg>, accessed 10 Mar. 2008.

UNITED NATIONS DIVISION FOR SUSTAINABLE DEVELOPMENT, 'Johannesburg Declaration on Sustainable Development', *United Nations Division for Sustainable Development* [website], updated 15 Dec. 2004, <http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POI_PD.htm>, accessed 11 Mar. 2008, <http://portal.unesco.org/education/en/files/30363/11035294683brief_Concept_of_ESD.pdf/brief%2BConcept%2Bof%2BESD.pdf>, accessed 10 Mar. 2008.

UNITED NATIONS DIVISION FOR SUSTAINABLE DEVELOPMENT, 'Agenda 21: Chapter 36', *United Nations Division for Sustainable Development* [website], updated 15 Dec. 2004, <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter36.htm>, accessed 17 Mar. 2008.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, 'Educating for a Sustainable Future: A Transdisciplinary Vision for Concerted Action', *United Nations Educational, Scientific and Cultural Organization* [website], published online 19 Aug. 1998, <http://unesdoc.unesco.org/images/0011/001106/110686eo.pdf>, accessed 17 Mar. 2008.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, 'UN Decade of Education for Sustainable Development (2005-2014)', *United Nations Educational, Scientific and Cultural Organization* [website], published online 15 Apr. 2004, <http://portal.unesco.org/education/en/files/30367/11035296383brief_Decade_2005-14.pdf/brief%2BDecade%2B2005-14.pdf>, accessed 17 Mar. 2008.

VANASSELT, W. (ed.), 'No end to paperwork', *World Resource 1998-99*, <http://earthtrends.wri.org/pdf_library/feature/ene_fea_paper.pdf>, accessed 30 Apr. 2008.

VEHKAMÄKI, S., 'The concept of sustainability in modern times', *Sustainable use of renewable natural resources – from principles to practices*, 34/2.2 (2005),

<http://www.mm.helsinki.fi/mmeko/tutkimus/SUNARE/pdf/22_Vehkamaki.pdf>, accessed 20 Feb. 2008.

VICHER, L., 'Climate change, sustainability and Christian witness - The Churches and Climate Change' *The Ecumenical Review*, Apr. (1997), <http://findarticles.com/p/articles/mi_m2065/is_n2_v49/ai_19496267>, accessed 21 Feb. 2008.

WAN, Z. W., 'Recycle - Or is it?', *Flickr* [website], updated 16. Aug. 2007, <http://www.flickr.com/photos/wanzw/1138691836/>, accessed 18 Aug. 2008.

WIKIMEDIA FOUNDATION, INC., 'Hans Carl von Carlowitz', *Wikipedia* [website], updated 19 Feb. 2008, <http://en.wikipedia.org/wiki/Hans_Carl_von_Carlowitz>, accessed 19 Feb. 2008.

WOODGROVE SECONDARY SCHOOL, 'History', *Woodgrove Secondary School* [website], <http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=5517>, accessed 06 Oct. 2008.

WOODGROVE SECONDARY SCHOOL, 'Green audit award presentation & ceremony 2008', *Woodgrove Secondary School* [website], <http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=32933>, accessed 06 Oct. 2008.

WOODGROVE SECONDARY SCHOOL, 'WGS campus map', *Woodgrove Secondary School* [website],

<http://www.woodgrovesec.moe.edu.sg/cos/o.x?c=/wbn/pagetree&func=view&rid=3271>, accessed 15 Oct. 2008.

WORLD RESOURCES INSTITUTE, 'Resource consumption: paper and paperboard consumption', *EarthTrends Energy and Resource* [online database], updated Dec. 2006, <http://earthtrends.wri.org/searchable_db/index.php?theme=6>, accessed 30 Apr. 2008.

ZEDAN, B. 'How to make paper', *Flickr* [website], updated 20 Sep. 2005, <http://www.flickr.com/photos/bzedan/sets/967347/>, accessed 06 Oct. 2008.

APPENDIX A

TABLE A-1

LIST OF INSTITUTIONS SURVEYED[404]

Level of education	Name of institution
Secondary Schools	Ahmad Ibrahim Secondary School
	Anglican High School
	CHIJ St. Joseph's Convert
	Henderson Secondary School
	Jurong Secondary School
	Zhong Hwa Secondary School
Junior Colleges/Pre-University Centres	Jurong Institute
	Nanyang Junior College
	Victoria Junior College
Tertiary Institutions	National University of Singapore

TABLE A-2

BREAKDOWN OF THE STUDENT POPULATION SURVEYED[405]

Student category	No. of students surveyed
Secondary Schools	333
Junior Colleges/Pre-University Centres	67
Tertiary Institutions	45
Total	445

[404] Victor R. Savage and Sharon Lau, 'Green issues: official policies and student awareness', in id., Clive Briffett and Sim Loo Lee (eds.), *Environmental issues in development and conservation* (Singapore : SNP Publishers, 1993), p. 13.

[405] *Ibid.*, p. 14.

APPENDIX B

TABLE B-1

LIST OF INSTITUTIONS SURVEYED

Level of education	Name of institution
Primary Schools	Boon Lay Garden Primary School
	Dazhong Primary School
	Raffles Girls' Primary School
	St. Hilda's Primary School
	Wellington Primary School
Secondary Schools	Dunearn Secondary School
	Naval Base Secondary School
	New Town Secondary School
	Telok Kurau Secondary School
	Zhenghua Secondary School
Junior Colleges	Anglo-Chinese Junior College
	Hwa Chong Junior College
	Pioneer Junior College
	Serangoon Junior College
	Victoria Junior College

APPENDIX C

1 NORTH BUONA VISTA DRIVE
SINGAPORE 138675
REPUBLIC OF SINGAPORE

Telephone: 6872-1110
Telefax : 6775-5826
CS-mailbox: GVT 036
e-mail: contact@moe.edu.sg

Personal e-mail address:
E-mail: Teo_Kie_Eng@moe.gov.sg
Sim_Lee_Nah@moe.gov.sg

Ministry of Education
SINGAPORE

EDUN N32-07-005 Request No.: **RQ53-07(08)**

27th August 2007

To: Principal of Primary Schools, Secondary Schools and Junior Colleges

STUDY ON "WATER PAPER RECYCLING SYSTEM IN SCHOOLS"

The Ministry has no objection to the research proposed by Mr Chua Ying Shiun Erik, a Master student at the National University of Singapore. **You may decide** whether or not to allow him to conduct the research in your school. If you do, please:

i) check that the approved research proposal should be adhered to;

ii) inform your teachers/pupils that participation in the study is voluntary and they need not provide any sensitive information (e.g. name and NRIC No.);

iii) record your school's participation by completing the form as shown in Annex A;

iv) note that the researcher is granted a period of 6 months starting from the date of this letter to complete the research.

2 If you require any clarifications, please contact the researcher through the contact number as stated in the application form. Thank you.

Yours sincerely

Teo Kie Eng (Ms)
Head, Data Administration 3
Data Administration Centre
N3207005/RQ53-07(08)

Public Service for the 21st Century

APPENDIX D

EDUCATING SUSTAINABILITY THROUGH PAPER RECYCLING IN SCHOOLS

- FEASIBILITY STUDY -

QUESTION:
In your opinion, is it feasible to implement this proposed waste paper recycling system in your school?

ANSWER:
Please choose "Yes" or "No" and state your reason(s).

☐ Yes
☐ No

Reason(s): _____
_____
_____
_____
_____