Preservation of Archives in Tropical Climates. An annotated bibliography

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This publication was issued by the International Council on Archives, The National Archives of the Republic of Indonesia and the National Archives of the Netherlands on the occasion of the international conference *The Preservation of Archives in Tropical Climates*, which was held in Jakarta 5-8 November 2001. It contains an extensive overview of currently available resources on issues in relation to preservation and conservation in tropical climates, focusing on books and writing materials, building and storage facilities, disaster preparedness and integrated pest management. The second part of the book consists over 1400 literature references.

2001, Paris/The Hague/Jakarta, International Council on Archives/National Archives of the Netherlands/National Archives of the Republic of Indonesia ISBN 90-74920-14-4

The webversion is derived from a revised version of the bibliography, published in Comma, 2001.3-4, Paris, ICA, ISSN 1680-1865

Foreword

Archives by their very nature are unique both as individual documents and as documents in context. Lost archives are irreplaceable, any loss is final, and in most cases reconstruc-tion is impossible. Archives from the past have been handed over to us by our ancestors, it is our duty and our privilege to keep them for our children and their childrens' children. Archives allow us to establish communications between past and future generations. We archivists are in this process the guardians of the continuity with previous and future generations of our nations.

Some of the records in our custody have come to us in an orderly manner well cared for by the creating agencies, other records are refugees of the turmoil of history, many, too many have been victims of war, arson, flooding or other kinds of manmade or natural disasters, and are partially saved or lost forever.

Whatever their past, the archival heritage in our custody is nevertheless threatened by both internal and external factors, such as the quality of component materials, rodents, mould, acidity, etc. Regrettably we have to add external factors of another kind, such as the physical ones of fire, water, dust and use and political ones like shelling, arson and ethnic cleansing.

Archives are generally considered to form the skeleton of the Memory of Humanity, by containing not only factual information but also the informational context in which other elements of life, for example paintings and sculptures, war and discovery, occupation and religion, can be placed and better understood.

However, by using the generic term 'archives' one implicitly accepts its limitations: archives are part of a European concept, based on Roman law, a concept that received a gun-point introduction in modern societies all over the world. Many societies outside Europe had developed an extensive oral and intangible heritage and advanced writing systems and preservation practices long before European colonists arrived with their own record-keeping systems, and with their European paper. Climatically well proven systems for 'memorising' data, meeting the needs of the local societies of that time, have been put aside as not suitable for 'European' administrations. In some cultures both systems cohabited, the European one providing core data, 'facts', the indigenous one providing circumstantial evidence of some importance for understanding local traditions relating, for example to religion, or to culture, or providing other kinds of information, or seen from another perspective, the occupying forces kept the official records, the occupied nations continued keeping the records of the indigenous people, be it in tangible or intangible form.

In essence the information system embodied in European archives was created to deal with property. In other cultures the information system dealt mainly with different kinds of data, like the location of fresh water (e.g. Australia), movement of herds (e.g. North-America) or the relationship between deities and man, or the continuity of generations.

I would like to note as an observation that, assuming script for storing data was introduced in accordance with local needs, one should keep in mind that even in highly literate cultures, elements of oral and other traditions are still in use. For instance, oral testimony in court becomes written evidence and a public record – and this can even include objects as evidence, such as the bullet that missed Gladstone. What is in a name? There are many good reasons to reconsider the validity of 'European' archival definitions for their applicability in non-European societies and to consider the acceptance of `data' or objects transmitted via other traditions as part of the corpus of historic data to be kept in archives repositories.

Thinking along these lines one might consider the 'Memory of Humanity' to include all that can be memorized in physical or intellectual form, be it landscape, nature or components of human life, like tradition, artefacts, ideas, and so forth. As this Bibliography deals with preservation of archives according to established tradition I will return to the safe side and concentrate on archives within the traditional definition.

However, before doing so I would like to dwell a little on the relative relevance of archives for the knowledge of the 'history of man', by relating archives to the voyage of the human species in time. According to many scientists `Modern Man' started after the last Ice Age, about 100,000 years ago to domesticate animals and to settle for a sedentary life. Modern Man added script to his utensils for preserving the 'Memory of Humanity' only about five thousand years ago. The earliest recordings of his writing – even when apparently official records – are to be found in museums and not in archives.

Writing is nowadays a reliable way for transferring information. How 'reliable' will it be in future? How can a message be conveyed to homo sapiens over a period of 5000 years or more? For instance, a message like: *keep out, radiation zone*, put on top of under-ground nuclear waste belts? What kind of 'sign' will be understood 5,000, 25,000 or 50,000 years from now, as a warning not to drill in the ground because of the danger of radiation? What material should one choose for preserving any sign for such a long period, paper, wood-blocks, parchment, microfilm, clay-tablets, palm leaves, rock, computer-tape or diskettes, acoustic systems? Will there be any institution keeping records over 5000 years old? Will records of that age be more likely to be kept in museums, as happens nowadays with records of 5000 years ago? What equipment will people have by then to decipher messages – computers, or only brains and reading glasses? Such questions are not easily answered. As a native Australian expression goes, 'rocks vanish, word remains'.

These questions open a domain of professional relevance, for instance, what about durability of data carriers, like paper, computer-diskettes, movie-film, clay-tablets; what about the presentation of 'data', like script of any kind, graphics, and so on, what about the chemical and physical fixation techniques that make data-carriers and data stick together (water in ink; magnetism; heat); what about instruments and 'brains' that make data understandable, and thereby turn data into information (several early scripts are still waiting to be deciphered).

Little is known about the expected life span of specific data-carriers apart from rock, of the 'sticking-material-technique' and of the 'equipment-brain-span' that makes information out of data (or even identifies possible data as such). Here is an example for the sake of the argument.

In modern archival literature one can read a lot about acidity and the ageing of paper. However, how much has been published on the life expectancy of a specific make of paper of a given era, exposed to a continuous high relative humidity; or a cyclical high and low relative humidity; or a continuous low relative humidity, combined with temperature, high, low, moderate or cyclical, combined with dust, exposure to sunlight, folders, boxes, administrators, archivists or users? Is any such data available? Is data available on the ageing of paper in thick-walled, heavily insulated repositories in a variety of climates? Are there data on what happens to paper in thin-walled repositories fitted with cooling equipment that functions a few hours per day only? Is any information available on what happens to records that are stored in properly conditioned repositories and consulted or listed in hot and humid searchrooms or office blocks? Do we have any idea of the relationship between storage conditions and chemical and physical decay of paper, photographic materials, and so on? Do we have any data for any formula that will enable us to make reliable estimates on the return on our investments in creativity, in staff-time, or in money? Do we have any that can be used as input for risk calculation, or as input for establishing priorities?

Here are some postulations. In some tropical climates – as has been established – it may take records, even if made of long lasting paper, only some 100 to 200 years to become dust. Before becoming dust they would have passed the no-use line (identical to a no-research line), and shortly after the no-touch line (identical to no-reformatting line or past-lamination line). In moderate climate zones the no-research line may be crossed after 1,000 years and the no-reformatting line after 1,500 years. Special problems are posed by newspapers. Most of those are printed on unstable paper of low quality. In some countries this kind of paper is also used for stationery. The no-research line of this kind of paper will be crossed in the tropics within 100 years, in more favourable climates within 400 years.

However, long before dust has become dust, the data may have faded away. Some carriers just lose the data they carry easily. For example, some makes of ink fade easily, other kinds 'eat' paper. Some kinds of photocopies do not tolerate sunlight, other kinds can, if not properly processed, be wiped out easily. Some kinds of stencil seem to lose contrast, etc. Poor quality of ink, of magnetism – submitted to chemical and physical processes as they are – will increase the speed of decay of carriers and their data even further, even when, by comparison, they are kept under stable conditions. One may conclude that according to the materials used and their environmental and office and repository conditions the life span of carriers and data may vary in the tropics from a few years for some materials to twice the life span of man for other materials and in moderate climate zones from one or more decades to 5-20 times the life span of man.

Preventative measures are generally consistent with the accepted guidelines for a professional preservation policy. Such a policy should include:

- measures to minimise the rate of deterioration;
- housekeeping routines to clean, protect and extend the life of materials;
- staff and user training programmes to promote and encourage correct handling and transport of materials;
- security measures and contingency plans for disaster control and recovery;
- protective measures, such as boxing, binding, and wrapping, to reduce wear and tear on materials;
- a substitution programme for replacing valuable or very brittle originals with surrogates such as microforms;
- conservation treatments to repair damaged originals;
- disposal programmes for materials of no further use;
- procedures for reproducing originals;
- procedures for the exhibition of materials within the institution or while on loan to another organisation.

The physical environment in which materials are stored will have a significant effect on their life span. Environmental conditions such as temperature, humidity, light and atmospheric pollution can each affect documents of any kind. Preventative measures should aim to achieve the best possible conditions for storing and using items. The process of decay can be slowed down considerably by creating favourable storage conditions taking into account the general level of air pollution, the possibility of creating a controlled climatic environment and the cleanliness of the storage facility. 'Greening' of archive buildings – i.e. use of low energy and low technology engineering; use of minimally toxic, environmentally friendly materials in construction; use of recycled materials; low running costs – should get top priority on the professional research list.

At the Annual Meeting of ICA of 1987 one of the participants made an interesting remark: 'preservation is a question of management, not of repairing.' Good archives management implies the proper organisation of an archives office. Proper organisation implies disaster awareness and preparedness, proper storage, security, handling, conservation, etc., and if applicable, reformatting. One has to set priorities and to evaluate the cost benefits of different types of action, be it passive preservation, active conservation or reformatting, against the importance of collections. The simplest preservation measures, good handling etc., are by far the cheapest. That is why there is a lot we can do.

The common way of preserving collections, all over the world is by reformatting the collections in priority order through microfilming or digitization, after having listed them, and then keeping the originals unused but in stable condition. Damaged documents should receive, if possible, conservation treatment. Again, if possible, documents should be placed in folders, folders in boxes, boxes in stacks. One should strive for an optimal climate for permanent storage, be it through air-conditioning 24 hours a day, seven days a week or through building and insulation techniques.

Many archivists are working along these lines, implicitly or explicitly. If the quantities to be considered are small, there are no real problems. A few hundred reels of microfilm will do. Most repair shops do a good job. There is no doubt about that. Reality, however, is different. What can one do with hundreds, thousands of files, each containing dozens or hundreds of sheets of paper, all filled with text and drawings, some of them torn and soiled, others brittle, and so on? What is to be done with the backlog? Current activities are well aimed, and often cost-effective, but the level of activities is disproportionate to the extent of the problem.

Traditional conservation techniques may be sufficient for coping with several kinds of mechanical, biological and chemical damage, but one should consider any irreversible technique to be a potential danger. For example, it has been reported that in some European countries major damage to records was due to their chemical treatment in the past. Even the use of lamination for stabilizing archive materials is questioned and could well turn out to be a counter-productive preservation process. However, for documents nearing the no-touch line, it may be the only solution for preservation for the time being.

On their own all archivists are minor players in safeguarding the elements of the Memory of Humanity entrusted to them. Two possible outcomes of a world wide performance analysis of this role of archive services could be a recommendation to globalize workshops for technical services, and to globalize storage facilities as well. Many barriers will have to be dismantled.

Globalizing intellectual access has been an odd idea. What else, however, will be the outcome of the introduction of electronic formats and electronic finding aids? One cannot cut communication lines in order to keep the electronic data on-site.

Globalizing storage facilities and technical services still sounds odd, but the profession should start considering such options. The Indonesian – Dutch co-operation sets an interesting example. Options for improvement of co-operation in the fields of micro-filming, digitization, restoration, computer storage capacity and training should be studied, sponsors should be identified and engaged.

Cooperation at institutional, national and international levels, in conjunction with libraries and museums, would be one of the ways of ensuring the better preservation of the Memory of Humanity. Progress in modern technology may assist in coping with some of the problems posed by both natural and man-made hazards and by the ever increasing quantity of archives to be kept. However, the information age will not solve the problems of record keeping, on the contrary it will only add more problems. No administration has produced more records, both in paper and in electronic format, than this era called the information age. Together all archives services worldwide take in accruals on an annual basis of a few hundred linear kilometers, or more, something like the distance between Jakarta and Jogjakarta. On top of this we receive huge quantities of electronic data, data that will have no significance if not prepared for transfer together with software and necessary documentation. And to add to this, one should not forget the masses of audio-visual materials, such as TV reels, audio tapes, still and moving film, etc.

The initiative of the Arsip Nasional Republik Indonesia together with the National Archives of The Netherlands in organising a seminar on preservation of archives in tropical climate zones and in commissioning a an annotated bibliography on preservation of archives in tropical climates could turn out to be a decisive step towards developing tropical archivology as a subject in its own right, a subject that should form the subject of one of the next ICA International Congresses on Archives. Such a tropical archivology should provide for best practices and standards for record keeping in tropical countries, and can only be developed in close co-operation between professional and other partners. The Jakarta conference was a first step.

Joan van Albada
Secretary General of the International Council on Archives

Preface

Everyone familiar with archive preservation will agree that it is more demanding in tropical climate zones than elsewhere. One might even say that archive management in tropical zones is more governed by the climate than by any other professional concern. The 'to be or not to be' of archives in such zones is dictated more by the climate than by any other influence; whatever the level of investment, the fact is that the climate is always hostile to the survival of natural polymers.

This bibliography is therefore written for all those who are interested in the typical problems developing countries face in safeguarding their archives. It is intended to make the numerous sources of information accessible, including those on the internet. As the preservation problems of archives, libraries and museums show many similarities it includes many titles from our cousins in preservation. The subjects dealt with reflect some of the most pressing and distinctive issues of tropical preservation. Part One chiefly consists of annotations and quotations from the listed authors. These are arranged in such a way that they can speak for themselves. Occasionaly, however, clarifications and additions are included. Other titles are arranged according to their particular subject. By using an inductive method this study offers more than the classic annotated bibliography. In Part Two the bibliographic data is listed alphabetically and arranged by chapter. The appendices contain a glossary of the many abbreviations used in the text and an extended list of addresses of all institutions mentioned, including their URL addresses.

It will not remain the static paper product the reader at present hold in his hands. In the very near future the European Commission of Preservation and Access (ECPA) in collaboration with the National Archives of the Netherlands, will publish it on their website, together with other surveys, as a searchable database. The ECPA and the National Archives intend to update these important sources of information on a continuous basis. as well as the URL and Email addresses which are constantly changing.

The research for, and publication of this volume has been made possible thanks to the financial support of HGIS (the Homogeneous Budget for International Co-operation of the Dutch Ministry of Education Culture and Science and the Dutch Ministry of Foreign Affairs) in the framework of the programme Towards A New Age of Partnership. (for more information about this programme see www.tanap.nl.) The initiative of the Arsip Nasional Republic Indonesia, the National Archives of the Netherlands and the International Council on Archives in producing it is a decisive step towards developing tropical archivology as a subject in its own right, a subject that should form the subject of one of the next ICA conferences.

The preservation of archives, the intellectual archival heritage of mankind, is a wonderful but difficult task. Especially when this archival heritage is built and stored in countries in tropical climate zones like Indonesia. Therefore we are glad to present this bibliography on *Preservation of Archives in Tropical Climates* which has been realised with the enthusiastic cooperation of the National Archives of the Republic of Indonesia, the National Archives of the Netherlands and the International Council of Archives. May it serve as a goad to the better preservation of archives in general and in tropical climates in particular and contribute to the understanding of the special problems facing preservation of archives in tropical climates.

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Part One

Preservation of Archives in Tropical Climates

Chapter 1 : Basic Concepts

1.1 *Introduction*

Our heritage is all that we know of ourselves; what we preserve of it, our only record. That record is our beacon in the darkness of time; the light that guides our steps. Conservation is the means by which we preserve it. It is a commitment not only to the past, but also to the future (Ward, 1989). To secure our records for the future is not an easy task. Libraries and archives all over the world face serious preservation issues. Whatever continent we focus on, we can find cultural heritage of many types, in many forms, each of which requires different preservation methods. It would be very difficult, therefore, to formulate a uniform policy for preservation. However, we cannot afford to sit on our hands.

Conservation has not a very long history as a full-grown profession. The world of paper and book conservation became manifest only some 30 years ago. Today conservation is an established profession. Yet, this development is mainly in the developed countries, since the developing countries had more pressing matters to concentrate on. But it is only now that western conservators have started to realise that the problems their colleagues face at the other end of the globe are different and often more complex than their own.

At the same time western institutions needing solutions for mass conservation problems profit the most from the advances in conservation sciences. Let us hope that this will change in the future. Developing countries often suffer from specific threats to their cultural heritage. Extreme temperatures and relative humidities often cause large-scale infestation of country-specific insects and moulds. In addition, non-western written traditions, including the writing materials, are frequently different from western ones. Although individual governments and multilateral institutions give support and aid, it is mainly according to western preservation strategies. National programmes for preservation, including specific research projects, are being established. Care should be taken not to impose the solutions to western conservation problems on developing countries. Preservation research should rather aim at a better understanding of typical non-western conservation problems (Porck et al., 2000).

To be informed on current conservation affairs will cost money. Many libraries and archives have had to end subscriptions to professional magazines because of cut backs in their budgets. However, with the arrival of the internet a lot of information is becoming more freely accessible and will contribute to a better and cheaper dissemination of knowledge.

Conservation in tropical climates is not a simple job. In 1966 the French archivist, Yves Pérotin said: ‘What an uphill struggle is the work of the tropical archivist.’ But let us not forget that failure is the mother of success.

The following paragraphs review some basic concepts and approaches that are relevant to conservation problems in the tropics. As there is much talk of tropical climate, attention is paid to what is actually understood by tropical climate. It is also explained that this bibliography is not only meant for conservators in archives, but that colleagues working in libraries and museums can profit from this study too. In fact quite a few references come from those fields of conservation. Many surveys have been published on almost all continents. They are a useful tool to make conservation needs manifest in a particular region. The same holds for the countless regional and country reports. To give an impression of international cooperation several impressive examples are listed at the end of this chapter. Without this international cooperation the field of conservation remains very limited for both the rich and the poor countries.

1.2 *Problems in the Tropics*

In general high tropical temperatures (and relative humidities) play a major role in accelerating the rate of chemical and biological degradation as well as providing a conducive atmosphere for the multiplication of tropical insects (Arnoult et al., 1995). According to the director of the National Preservation Office of the Australian National Library, Jan Lyall, there are several factors that make archival life very difficult in the Asia / Pacific region but they are applicable to most developing countries as well

- tropical climates;
- political unrest/war;
- the lack of acknowledgement of the need to preserve by the government;
- selling of valuable heritage material to fulfil basic needs of the local population;
- physical isolation;
- differences in language and literacy skills.

Governments must acknowledge the importance of libraries and archives and the need to preserve a nation’s documentary heritage before truly effective preservation programmes can be developed. Funding of library activities, including preservation, is critically linked to the political system in operation. Governments in most developing countries allocate a very low priority to libraries. Library and archive budgets are often so low that there are insufficient funds to acquire adequate supplies of library materials, to provide suitable housing for the collections or to operate normal library or archive services: preservation is seen as a luxury. Even in developed countries budgets for libraries and archives are shrinking and preservation activities frequently are drastically cut (Lyall, 1997). In this respect preservation problems in Latin America are, in fact, often not that different from North American. However, the scale of some problems in Central and South America can appear more daunting as the human and material resources available are often extremely limited (Raphael, 1993). Yet, lack of funds is surely not the only problem although it is often put forward as an excuse for a policy of ‘laissez-faire’ (Strickland, 1959).

The deterioration process in the tropics is very complex, and it is difficult to determine whether there is one culprit at work at a time, or whether several forces are simultaneously active (Agrawal, 1984). These destructive forces can be classified into three groups – the physical (heat, sunlight, dust, sand), the chemical (moisture, gases, pollutants), and the biological (fungi, bacteria, insects, rodents). The constant year-round heat speeds up the rate of deterioration. The rule of thumb is that every 10 °C rise in temperature halves the life of a book (Thomson, 1994). Additionally, ultraviolet radiation and other energy elements of light, combined with high temperature, result in an acceleration of oxidation and hydrolysis. The effects of chemical contamination are greatest when air is at its saturation point and condensation occurs. In itself a high moisture content has already a great corrosive effect on organic materials. When constant high relative humidity combines with high temperature and is left uncontrolled, deterioration is extremely fast. The same fatal combination of heat and moisture creates a suitable environment for biological agents. Fungi remain dormant in low relative humidity, but when it reaches seventy percent they thrive and multiply. Insect pests are silent destroyers. Often nocturnal, they can do irreplaceable damage quickly and secretly. In addition to these relatively gradual deterioration agents, the tropics are subject to sudden and violent natural disasters. The tropics are, in fact, about as far as one could get from any vision of an ideal library or museum environment (Baish, 1987a).

The majority of the countries in tropical climate zones were at one time or another under colonial rule. The impact of colonialism on preservation and conservation in the newly formed states is still noticeable today. Research into the establishment of information services in Africa has shown that the colonial administrations had little regard for the establishment of national institutions to cater for archives and libraries. On the eve of their independence many an African country had nothing they could refer to as a national archive and/or library. Even long after independence some countries still do not have these institutions. It has been argued that the failure by some colonial administrations to lay some form of foundation for the establishment of information services has contributed greatly to the lack or weak preservation and conservation programmes in Africa (Khayundi, 1995). Ahmed Huq notices that western observers, particularly the former rulers, of course, view this differently (Huq et al., 1977). In other countries, according to Plumbe, libraries have resulted from the mildly beneficial administration of colonial powers (Plumbe, 1959a). Unfortunately, it appears that the lack of proper recognition of the need for conservation is also omnipresent outside the African continent.

1.3 Tropical Climate Zones

Generally the tropical zone is defined as the area of land and water between the Tropic of Cancer (latitude 23.5° N) and the Tropic of Capricorn (latitude 23.5° S). Occupying approximately forty percent of the land surface of the earth, the tropics are the home to almost half of the world's population. The area may be envisaged as a hot, moist band around the equator, typified by little seasonal change of temperature. There are variations in climate within the tropics, however ninety percent of the tropical zones embody hot and humid climatic regions, whether permanent or seasonal. The remaining ten percent is desert-like, and characterised as hot and dry (Baish, 1987a).

The climates prevailing around the globe are primarily influenced by the sun's energy heating up the land and water masses. At regional level the climate is influenced by altitude, topography, patterns of wind and ocean currents, the relation of land to water masses, geomorphology, and the vegetation pattern. Accordingly, the tropical and subtropical regions can be divided into many different climatic zones, but for practical reasons, usually three main climate zones are considered:

- the hot-arid zone, including the desert or semi-desert climate and the hot dry maritime climate;
- the warm-humid zone, including the equatorial climate and the warm humid island climate;
- the temperate zone, including the monsoon climate and the tropical upland zone.

This division into three climatic zones is very generalised since many areas exist with differing climates or a combination of types. Local conditions may also differ substantially from the prevailing climate of a region, depending on the topography, the altitude and the surroundings, which may be either natural or built by humans. The presence of conditions like cold air pools, local wind, water bodies, urbanisation, altitude and ground surface can all influence the local climate strongly (Gut et al., 1993).

As the features of each zone are different it is obvious that this will result in different problems and consequently different preservation solutions. However, the varied forms of tropical climate in different regions make it necessary to generalise in this study. Although we acknowledge the importance of the issue it is beyond the scope of this bibliography. Specific climatic zones are mentioned occasionally if the author so indicates.

For ease of reference, the definition north-south facing is used in the sense of the northern hemisphere. For the southern hemisphere the terms have to be reversed. For example, where north orientation is recommended, then this is valid for the northern hemisphere only. For the southern hemisphere the orientation would naturally be south.

1.4 Archives, Libraries and Museums

The title might suggest that this survey is about archives only. This is not entirely true. Many other institutions face the same or similar problems, in particular libraries and museums. Archives, together with libraries and museums, all take on the onerous task protecting and preserving a particular part of our common cultural heritage. They are both specific yet complementary institutions. Each approaches preservation differently. It is not so much the physical characteristics of the objects preserved as the method of preservation of their informational content which distinguishes archives, libraries and museums (Gauye, 1984). One specific reason for the development and preservation of archives, as formulated in modern development terminology, is its contribution to *good governance* as sound record keeping. This is essential to an effective and efficient system of public administration. The holdings of museums in developing countries also have particular characteristics as some art historians assume the absence of a willingness to control or prevent the physical deterioration of cultural property in non-western societies. Still, there are ample examples where the opposite holds good (Nicklin, 1983b).

It is also recognised that museums, especially in the developing world, play an essential role in educating the people. As for the libraries, UNESCO (United Nations Educational, Scientific and Cultural Organization) had already realised by the 1960s that the development of a global literacy campaign would fail if the development of national and regional library networks was left behind. It was imperative that attention be given to the preparation of reading materials, especially vernacular literature, for the newly literate adults (Milburn, 1959). One way or another archives, libraries and museums are the *sine qua non* for the enhancement of the national and cultural identity of a nation. The identity, as well as economic recovery, is seen in many ways to be linked with the survival of the cultural heritage (Dean et al., 2001).

Clearly they all confront the same basic difficulties in safeguarding their holdings under severe climatic conditions. That is why the preservation literature of library and museum organisations has been considered as well, although the main concern of this bilbiography remains with the preservation of archives.

1.5 Surveys

International and national surveys and questionnaires can give worthwhile insight to the conservation needs of national archives. In addition they give us quantitative and qualitative data on the state of conservation, a prerequisite for drawing up any preservation programme (Idsala, 1995). To quote Cunha from his *Methods of evaluation to determine the preservation needs in libraries and archives* 'every library and archive must determine its own preservation needs from which to develop its own conservation programme.' This work provides the framework for undertaking the survey. It provides sample forms that are very useful for recording survey data. It does not, however, address in great detail the setting of priorities, and is perhaps overcautious in some recommendations (Cunha, 1988).

In 1978 UNESCO conducted a conservation facility survey in the Middle East. In all the Arab states only 3 countries maintained a conservation department (Egypt, Sudan and Libya).
This may be taken as an indication that the development of technical services in archives in the Arab states is very rudimentary, an impression consistent with the known general state of development of archives in those countries (Kathpalia, 1978).

In Nigeria 42 libraries answered another early questionnaire in 1980-1982. The case of library conservation in Nigeria, the most populous African country, may be considered typical for a developing country as well as for a tropical country. The incorporation of insecticides in the process of paper production, and the design of library buildings for conservation in the tropics were among the interesting topics discussed. The author also expressed the need for greater research into conservation problems unique to Nigeria and the tropics. (Alegbeleye, 1988). Other African surveys on preservation are *Adikwu, 1987; Janssen et al., 1991; Khayundi, 1988 and 1995; Kremp, 1993; Kukubo, 1995; Mazikana, 1995; Mbaye, 1995; Musembi, 1999; Sonnet-Azize, 1995; Weilbrenner et al., 1988.* In the Annex of the Proceedings of the Pan-African Conference in Nairobi 1993, twenty-eight countries reported on the state of preservation of their library and archival materials (Arnoult et al., 1995). The latest survey on African preservation was organised by the JICPA (Joint IFLA-ICA Committee for Preservation in Africa) and published in 2001 (Coates, 2001).

In an overall UNESCO survey of all national libraries and archives, professional organisations and research institutes, one of the questions concerned main research needs in preservation and conservation in the future. Of the 69 respondents 10% came from less developed countries, and stressed the need for simpler, more accessible solutions, equipment and materials, trained staff, and literature oriented to the needs of tropical countries (Clements et al., 1989).

The National Diet Library (NDL) conducted a *Library Preservation Needs Survey of National Libraries in Asia* in 1992. The aim of the survey was to ascertain and evaluate preservation issues and needs in the Asia region. More than 100 items were surveyed in a wide range of areas. The questionnaire was sent to 20 libraries in East and Southwest Asia responsible for collecting and preserving materials at the national level. Twelve libraries, including the NDL, responded. Some of the survey findings are of particular interest: only a few countries had a national policy for preservation of library materials, or had started a nationally coordinated cooperative preservation programme, 6 libraries responded that they were making efforts to raise national preservation awareness, 3 libraries had conducted a microfilming programme, 2 libraries considered emergency preparedness very important, and many libraries requested support, information and training from the NDL and the PAC Regional Centre (Kaihara, 1993).

In 1995 the former Commission on Preservation and Access published an inventory of preservation needs of Latin American libraries and in the same year Baker published a Latin American overview of current trends in conservation (Baker, 1995; Hazen, 1995).

An impressive stocktaking questionnaire on archival development was sent to most members of the ICA (International Council on Archives) in 1993 (Roper, 1996b). About half the 123 respondents came from developing countries. It became clear that factors like economic forces, political events and natural disasters, outside the control of national and international archival organisations, have often been of major significance in their impact on archival development. In many developing countries the combination of these adverse forces has limited growth and in some cases has even resulted in a deterioration of the archival situation compared to the results of earlier surveys (Laar, 1985; d'Órleans, 1985; Tanodi, 1985; Mazikana, 1992). In terms of conservation archives continue to be housed in buildings which are inadequate both in their storage capacity and in their suitability; equipment is inadequate and insufficient, often obsolescent, if not obsolete; maintenance and the supply of the materials to operate it are erratic. Nevertheless, the majority of the respondents highlighted the positive rather than the negative influences on archival development in their countries.

Rhys-Lewis even noticed a growing interest in archive and library conservation in developing countries in 1999. At the same time he points out that the role of conservation as a specialism within European archive services took approximately 50 years. This development did not always happen as a result of careful strategic planning. He contends that the developing countries could benefit from the European experience, in the shaping of effective preservation strategies (Rhys-Lewis, 1999). Two years earlier he listed the preservation and conservation needs and problems of the upper regions of Southeast Asia, a region where war and civil strife have caused further destruction and have left libraries and repositories destitute of the financial and personnel resources needed to bring about change (Dean, 1997).

1.6 Country and Regional Reports

Many country reports are published that reflect the state of art in terms of conservation (Kuba, 2001). They can be useful for those who want more insight into a particular region or country. However, many reports only allow a superficial insight. For the museum world in Africa the bibliography by Gerhard is of particular interest (Gerhard, 1990).

The results of numerous ICA expert missions appear in the biennial ICA journal *Janus, revue archivistique*, see for instance the 1996 special issue, and also in their journal *Archivum, international review of archives.* Multilateral organisations, in particular UNESCO, also undertake different missions to map conservation needs, to evaluate conservation projects, etc. UNESCO mainly published these results in the RAMP (Records and Archives Management Programme) study series. A selection of these reports can be found in the section *Preservation and conservation – preservation in developing countries – literature.*

1.7 Projects and Programmes

The role of international organisations in preserving our world heritage cannot be stressed enough. For example, not long after UNESCO was founded in 1948, an archival expert meeting was convened (Roper, 1996a). There has been progress ever since. Most western countries have their own international development programmes and some bilateral assistance goes into archives management and preservation (Archer, 1996; Murray-Lachapelle, 1999; Olofsson, 1988; Söderman, 1999). For a guide on institutional help in librarianship in developing countries see *Sandell, 1996.*

Different multilateral organisations and international professional institutions give more large-scale aid but in general the initiatives of international cooperation should be more coordinated (Dean et al., 2001; Noerlund et al., 1991). In an interesting article Kukubo reviews the areas of actual and potential cooperation in preservation and conservation in Eastern and Southern Africa (Kukubo, 1995). The success of a preservation programme that involves the cooperation of several agencies would need the coordination of its activities by a local agency (Berrada, 1995). The need for regional cooperation in Africa is stressed by *Sonnet-Azize, 1995.* International projects, however, can also raise politically and culturally sensitive issues. When well-meaning foreign scholars obtain funds to help local repositories to preserve their valuable artefacts, conflicting interests can come into play. It should be emphasised that balancing the needs of local ownership with the pressures for global access and the preservation community's belief in the notion of global responsibility towards the world's cultural heritage, is not always easy (Lindsay, 2000; Roberts, 2001).

Perhaps the digital highway is the solution to at least one form of global access. The Council on Library and Information Resources (CLIR) is taking advantage of the trend towards virtual education and has started to develop web-based tutorials on preservation and conservation for use in Southeast Asia. The tutorials will enable librarians, archivists, etc. to acquire basic and reliable preservation information, and to develop strategies and responses to preservation challenges distinctive to their climate, culture, resources, and content. The first modules are scheduled for implementation by summer 2002 and after evaluation in Southeast Asia CLIR anticipates adapting the modules for use in other regions in the world.

On tropical librarianship in general see *World Librarianship, focusing on librarianship and socio-economic development in Africa, Asia and Latin America*. This journal is the continuation of the *Third World Libraries* that was published from 1990 to the summer of 1996. It is published by Rosary College Graduate School of Library and Information Science in Illinois, USA. A.M. Abul Huq published an interesting bibliography on world librarianship, which is an indispensable reference tool for international and comparative librarianship (Huq, 1995). This publication is a continuation of his earlier work covering the period 1960-1975 that presents the literature of an important developmental period in the globalisation of library and information services (Huq et al., 1977). In this respect the *International Journal of Libraries and Information Services, Libri*, also publishes interesting articles see e.g. *Libri 1997(47/3).* See also *Cloonan, 1997b; Evans, 1995* and *Faber, 1994.*

1.7.1 UNESCO

From its earliest days the United Nations Educational, Scientific and Cultural Organization (UNESCO) has been involved in international archival development. It was responsible for convening the 1948 experts' meeting, which resulted in the formal establishment of the International Council on Archives (ICA) in 1950. As the international archival community grew and expanded beyond Europe and North America, so did UNESCO's and ICA's interest in and support for that community. Support has been provided to individual countries or groups of neighbouring countries from several UNESCO programmes as well as from other UN sources (e.g. UNDP, United Nations Development Programme). It is good to know that almost every country has its own local UNESCO library.

1.7.1.1 RAMP

In order to meet the needs of member states in the specialised area of archive administra-tion and records management particularly in developing countries, the Division of the General Information Programme of UNESCO established a long-term Records and Archives Management Programme (RAMP) in 1979. The basic elements of RAMP reflect and contribute to the overall themes of the General Information Program. RAMP thus includes projects, studies and other activities. UNESCO regularly publishes specialist studies and guidelines on records and archives management (RAMP studies), which cover basic issues of records and archives management such as:

- archival infrastructure development including archival legislation;
- training and education;
- protection of the archival heritage;
- promotion of the development and application of modern information;
- research in archival theory and practice.

The majority of the studies, mainly those published after 1996 are available on-line. For older publications on archives by UNESCO, or published with their assistance, see *Evans, 1983*. The drawback is that the specialist publications are very quickly outdated.

1.7.1.2 Museum International

An interesting UNESCO publication is the quarterly *Museum* published since 1948. In 1992 it changed its name to *Museum International* and is now published in five languages (Arabic, English, French, Russian and Spanish). It is a must for those who want to keep abreast of the many aspects of museum life all around the world. Each issue features a theme of particular interest e.g. *Museum, 1987 (156): Staff training* and many an issue is dedicated to conservation e.g. *Museum, 1982 (34/1)* or to museums of a particular developing country or region e.g. *Museum, 1976 (28/4): Africa*. The magazine provides a clearinghouse for the exchange of views through case studies, on-site reports, interviews, and informed editorial commentary. For further information see the UNESCO-website.

1.7.1.3 Memory of the World

In 1993 UNESCO initiated the *Memory of the World* programme. Documentary heritage reflects the diversity of languages, peoples and cultures. It is the mirror of the world and its memory. But this memory is fragile. Every day, irreplaceable parts of this memory disappear forever. UNESCO has launched this programme to guard against collective amnesia calling upon the preservation of the valuable archive holdings and library collections all over the world ensuring their wide dissemination. The objectives of the programme involve preservation by the most appropriate techniques, access without discrimination and the distribution of the results to the widest possible public (see also Ornager, 2000).

1.7.2 ICA

The International Council on Archives (ICA), as the international professional organisation, is concerned with all aspects of the management of records and archives throughout their life-cyle. Where UNESCO provides funds for international development, ICA supplies the brains and muscles. Its general objectives are to encourage and support the development of archives in all countries, so as to preserve the archival heritage of mankind; to promote, organise and coordinate, on the international level, activities in the field of records and archives management; to establish, maintain and strengthen relations between archivists of all countries and between all institutions, professional bodies and other organisations; and to facilitate the interpretation and use of archival documents by making their contents more widely known and by encouraging greater ease of access to them. To facilitate its work throughout the world ICA has established regional branches in the non-European regions. Each of these ten regional offices controls its own affairs and publishes its own journal. The earliest branch (1968) was SARBICA, the ICA Regional Branch for Southeast Asia.

Broad issues of professional concern are discussed every four years at the International Congresses on Archives, which incorporate open meetings of ICA sections and committees as well as plenary sessions and business meetings. In 1975, following a general conference held in Dakar (Senegal), ICA established an International Archival Development Fund (FIDA) to provide top-up aid to archives in developing countries. Together with UNESCO ICA established the International Microfilming Programme for Developing Countries to assist national libraries in exchange or purchase of microfilm copies. ICA also facilitates the dissemination of professional and technical good practice through publications like the journal *Comma* (a merger of *Archivum, Janus*, and *CITRA-proceedings*) and their series of Studies.

1.7.3 IFLA-PAC

The International Federation of Library Associations and Institutions (IFLA) is a worldwide, independent, non-government organisation with a membership of 1,300 in more than 130 countries. Its members are library and related associations, libraries and similar institutions, institutional affiliates, and individuals. Its aims are to promote international cooperation, discussion, and research in all fields of library activity. It considers all aspects of library work to be within its province and strives to extend its membership to all countries. IFLA has a complex organisational structure with, amongst others, five Core Programs, one being the Preservation and Conservation (PAC) Core Program.

Unlike other Core Programs the IFLA-PAC Programme operates from a number of national libraries. The International Focal Point is at the Bibliothèque Nationale in Paris, France and there are six Regional Centres. The programme has one major goal to ensure that library and archival materials, published and unpublished, in all formats, will be preserved in accessible form for as long as possible. In 1986 this programme set up a network of Regional Centres to deal with preservation issues around the world (Appendix II). The PAC Programme publishes a newsletter, *International Preservation News*, three times a year in English, French and Spanish, free of charge. Issue number 24 from May 2001 is totally dedicated to *Preservation in Asia and the Pacific* (see also Blanco, 1988).

Next to IFLA there are, of course, plenty of regional library associations. To mention one example: the Congress of Southeast Asian Librarians (CONSAL). It was founded in Singapore in 1970 in response to a growing sense of Southeast Asian identity, fostered particularly by the formation of the Association of Southeast Asian Nations (ASEAN). Its main mission is to promote library and information development in the region and to lead the region towards greater participation in the international information community.

1.7.4 Pacific Manuscript Bureau

The Pacific Manuscripts Bureau (PMB) is one of very few long-term archival projects in the world based on international cooperation. For 33 years it has responded to the twin imperatives of academic research requirements and the need to preserve the documentary cultural heritage of the Pacific islands. The Bureau is small in scale but nevertheless has a strong reputation, a resilience born out of the necessity of its task and an enormous amount of support (Cunningham et al., 1996).

1.7.5 NRLC

The National Research Laboratory for Conservation of Cultural Property (NRLC) is a scientific institution, supported by the Indian government, established in 1976 to give a scientific footing to the conservation of cultural property in India. In its formative stages, the NRLC was developed with assistance from the UNDP (United Nations Development Programme) and UNESCO (United Nations Educational, Scientific and Cultural Organization), and now it is an associated member of ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property). To achieve this end, NRLC carries out research in materials and methods of conservation and diagnostic investigations, imparts training in preventive and curative conservation, disseminates knowledge in conservation and related areas through library and information service, provides technical assistance in the development of conservation facilities. The NRLC has developed and standardised a good number of methods for the conservation of different types of objects and for the analytical study of cultural property. It has also conducted several workshops on preventive conservation and training programmes in curative conservation for candidates from South and Southeast Asia.

1.7.6 APOYO

The Asociación para la Conservación del Patrimonio Cultural de las Américas (APOYO), Association for the Conservation of the Cultural Patrimony of the Americas, is an informal group of international members with the mission of supporting the conservation and preservation of the material cultural patrimony of the Americas (see Torres, 1994 and 1997). It was started in 1989 by interested members of the AIC (the American Institute of Conservation of Historic and Artistic Works) but has functioned independently. The main goals of APOYO are to bond professionals working in the conservation of Latin American cultural heritage, to promote high standards and to inform members in their native languages. To meet this need, the immediate objective was to promote and accelerate the exchange of information on conservation and preservation issues. APOYO has promoted this exchange through an outreach programme. Today the strategic APOYO-network includes approximately 4,000 conservation and preservation professionals, and continues to grow. These professionals are drawn from throughout the Americas, as well as Spain and other countries. Since 1990 APOYO has produced a newsletter consisting of one or two issues a year. Currently it is the only publication on conservation issues in Spanish reaching such wide audience. A directory of individuals and institutions involved in the conservation and preservation of the cultural patrimony of the Americas was published in 1996, in 1998 and in 2000. Useful information, especially significant translated preservation literature, can also be found on the website of the *Bibliotheca Nacional de Venezuela* (National Library of Venezuela). On the website *Conservation online* (CoOL) Whitney Baker has added several pages on Conservation in Latin America.

1.7.7 CECOR

The main objective of the Brazilian Centro de Conservação e Restauração de Bens Culturais Móveis (CECOR), the Center of Conservation and Restoration of Cultural Movable Properties at the Federal University of Minas Gerais, is the application of scientific techniques for the protection of the Brazilian cultural patrimony. This way CECOR wants to contribute to the protection and the study of the worldwide patrimony. The main areas of research are the scientific analysis of works of art in order to increase knowledge of the constituent materials and artistic techniques, and preventive conservation to understand better the physical, chemical and biological processes involved in the ageing and deterioration of artefacts. They have a very interesting website in Portuguese with some publications on preventive conservation online. They also host the CPBA, Projeto Conservação Preventiva em Bibliotecas e Arquivos (Project on Preventive Conservation in Libraries and Archives). The project aims to propagate preservation knowledge of the documentary heritage by dissemination and exchange. Its activities are carried out in cooperation with a great number of institutions. The CPBA has already translated 53 titles on preservation into Portuguese and recently published a manual on Microfilming in Archives. They also publish a Map of Preservation. Also worth mentioning are the web sites of ABRACOR, the Brazilian Association of Conservators and Restaurators, and *Arquivo Nacional*, the Brazilian National Archives.

1.7.8 GCI

The Getty Conservation Institute (GCI), a programme of the J. Paul Getty Trust since 1982, engages in activities dedicated to furthering conservation practice and education in order to enhance and encourage the preservation, understanding, and interpretation of the visual arts- broadly interpreted to include objects, collections, architecture, and sites. The Institute serves the international conservation community through scientific research into the nature, decay, and treatment of materials; in education and training; model projects in the field; and the dissemination of information through both traditional publications and electronic means. They initiated several fascinating research projects such as Collections in Hot and Humid Environments, Latin American Consortium, Performance of Pollutant Adsorbents, and the Maya Initiative (see *GCI website*).

Chapter 2 : Preservation and Conservation

2.1 Introduction

The art of preservation is as old as human civilisation itself. In a way it may be said to derive from the instinct of self-preservation common to all animate beings (Kathpalia, 1973). In spite of everything it seems we want to keep the past alive. Yet, we have to keep in mind that the cycle of nature dictates that all things of organic matter will decay. Thus we can only expect to increase the life expectancy of our paper-based material heritage, the core of our archives and libraries.

Below we will pay attention to the confusing terminology in preservation, introduce the preservation pyramid and make some notes on preventive conservation. Preservation in developing countries is a profession in itself, not only because of the difficult climatic circumstances but also because the artefacts in non-western cultures are quite different in nature than the western ones. For example lamination is still quite popular in the tropics, although in many developed countries this conservation technique is out of favour. More attention to appropriate technology in conservation could contribute to solving the enormous problems archives face in the poorer countries. The importance of traditional conservation techniques that most local conservators are unfamiliar with, should not be underestimated. The application of traditional techniques would certainly add to the integrity of the records and would increase their life expectancy.

2.2 Terminology

Among both conservators and curators there seems to be a veritable tower of Babel as to what is understood by preservation and conservation. Many organisations and authors have dealt with preservation terminology. For our purposes it is not practical to continue this discussion. The most important point is that at least all conservators define their own terms clearly so that their colleagues know what they mean. At the very least it will lessen the confusion of tongues. MacKenzie gives very broad definitions, which more or less cover the whole field of conservation (MacKenzie, 1996):

- *preservation*, in its current meaning in the archive world, refers to everything which contributes to the physical well-being of the collections;
- *conservation*, or direct physical intervention with the material, is only one part of preservation;
- *indirect preservation* includes the building, archive storage methods, security against threats, and handling;
- *preservation by substitution* or *reformatting*. This means making copies of the records, normally on microfilm, and then using the copies in place of the originals, thereby reducing wear and tear on the latter and preserving their condition.

The Memory of the World programme refers to the different terms as follows (Memory of the World-website):

- *preservation* is the organisation and programming of all kinds of activities regarding conservation of the collections in general;
- *conservation* is a concept that includes *preventive conservation* which aims to reduce the risk of deterioration: environmental control, regular maintenance and protection of the collections by using appropriate treatment, anti-theft devices and creating surrogate documents for heavily-used original documents.

2.2.1 Preservation Pyramid

To clarify the jumble of conservation terminology the National Archives of the Netherlands developed the Preservation Pyramid. At the bottom of this model is the section of preservation from which the entire collection benefits and at the top is the section from which only one object benefits from the actions of the conservator. The Preservation Pyramid contains four components:

- *preventive conservation* stands for all direct and indirect steps and provisions that will optimise the environmental conditions, and the preservation of and access to the object in order to prolong the life span. To start with it encompasses a clear line of policy that includes training, attitude building and professionalization of all staff;
- *passive conservation* stands for all direct and indirect steps directed towards the prolongation of the life span of objects. It includes good house keeping, air purification, air conditioning, repository hygiene and repository monitoring. An important feature of passive conservation is the survey of the physical condition of the collection;
- *active conservation* stands for all direct and indirect steps and actions on objects in order to prolong their life span. It includes re-boxing and re-wrapping objects, cleaning objects, mass-deacidification and disinfecting. This phase in conservation involves tasks that can be performed by people who are not trained conservators;
- *restoration* stands for all actions taken to prolong the life span of the object in its perceptible appearance in compliance with the rules of aesthetics and ethics, while maintaining its historical integrity. As it is the work of highly trained conservators who work on individual objects this is the most expensive and time-consuming phase in preservation.

2.2.2 Preventive conservation

One of a museum's primary purposes is to ensure that its collections are available for future generations. A popular image is of white-coated conservators working in laboratories to stabilise and repair items that have suffered from damage or neglect. This is 'remedial conservation'. It is, however, more efficient to prevent decay from occurring in the first place. This is preventive conservation. Deterioration is a continuous, natural process. It can, however, be slowed; indeed, science has suggested ways in which the natural lifespan of most museum objects can be extended. Many of these techniques are based on common sense and good housekeeping. However, these must inevitably be reinforced by the results of current research, and access to specialist information is vital if an informed approach is to be taken (Read, 1994).

Knowing and identifying problems of conservation in a tropical environment and considering developments is hard to understand and pinpoint. The emphasis ought to be laid on preventive conservation (Dartnall, 1988). After all prevention is better than cure. This holds especially true for developing countries that cannot allocate sufficient financial means to preservation. At the same time the more prosperous countries consider preventive conservation as a major cost-saving measure. Indeed, because preventive conservation considers the welfare of whole collections instead of the treatment of individual objects, it allows the more efficient use of limited resources for the benefit of a larger part of our material heritage. Perhaps that is why preventive conservation, the management of the environmental conditions under which collections are housed and used, has made large strides in research and application (GCI-website).

Unfortunately, not all managers are convinced of the necessity of preventive conservation. During her stay in Malaysia Margaret Child noticed that librarians at the National Library were not interested in spending the funds necessary for developing an infrastructure that would allow a programme to gain momentum and mature. Rather, they wanted to achieve faster results. Basic preservation efforts such as simple repair or protective re-housing, used in a consistent and co-ordinated program, are more effective than ad hoc initiatives (Child, 1997).

Many precautions can be taken right at the start in the construction and design of the building (see section on *Building*). Storage conditions also offer many opportunities to prolong the life span of the objects (see section on *Storage*). See also *ARAAFU, 1991; Beck, 1996; Brandt, 1994; Guillemard et al., 1990; Maidin Hussin, 1985; Raphael, 1993; Read, 1994; Souza, 1993 and 1994; Staniforth, 1997; Torres, 1996.*

2.3 Preservation in Developing Countries

In developing countries with low economic performance, it is understandable that neither facilities nor the political climate exist to safeguard the cultural heritage in preference to higher priority needs (Masao, 1987). Despite this as early as 1918 the All India Conference of Librarians, held in Lahore, Pakistan and presided over by the Librarian of the Imperial Library, Mr. Chapman, passed a resolution on ‘Preservation of Book Paper’ (Banerjee, 1997). Nevertheless it took many years before preservation was recognised as a vitally necessary component of collection development (Lan Hiang Char, 1990).

One of the early advocates, and perhaps propagandists, of tropical librarianship and tropical conservation was Wilfred J. Plumbe. In his capacity as librarian of the University of Malaya (Malaysia) and later of the Ahmadu Bello University in Nigeria he published a number of articles and books on the specific problems of safeguarding archival and library materials in the tropics. His bibliography of 1958 is now outdated, nevertheless the updated reprint from 1964 shows that it was in great demand and probably the only one of its kind at that time (Plumbe, 1958 and 1964b). Plumbe noticed in 1964 that there was a need in many tropical countries for book pathology centres where insect pests could be identified promptly, and where advice on their control, and on other aspects of book preservation, could be readily obtained. He also noticed the need for re-examination of book preservation problems by publishers and the book trade in general. Both ideas, though almost 40 years old, could be reconsidered today (Plumbe, 1964a). His book on tropical librarianship from 1987 is actually a compilation of articles, mainly from the 1960s (Plumbe, 1987a).

Another pioneer in this respect was the French archivist Yves Pérotin who in 1966 published a manual on ‘tropical archivology’, which he considered a sub-discipline of archivology seen from an exclusively material point of view. He stated clearly that the manuals so far had been written in non-tropical countries. They dealt with questions in the terms that were valid for their own climates as if they were suitable for the whole world. The book consists of two quite distinct parts: general archivology and tropical archivology proper, written by different authors with extensive experiences in the tropics. This manual of tropical archivology was certainly of great value at the time and provided archive keepers in tropical countries with simple, practical information (Pérotin, 1966).

Over the past 40 years conservation has developed into a true profession with educational levels as high as university. Almost everywhere, the preservation of cultural heritage is a subject readily discussed at meetings, but practical measures are often slow to follow. It should be remembered that it takes longer to organise a national service for the protection of cultural heritage than it does to build a large factory, and those who are anxious to preserve the vestiges of the past must be extremely patient (Coremans, 1965). Because of intensive use of microfilm technology in Southeast Asia preservation treatment of the originals has, in some cases, not been a high priority, and long-term sustainability has not received sufficient attention (Dean et al., 2001). That is why it is of the utmost importance to revitalise public awareness of the value of traditional literature. Acceptance of a preservation project and active participation of local people in preservation work is a prerequisite for success (Hundius, 2000). The state might be willing to invest in safeguarding their national heritage only when people themselves recognise the significance of their writing traditions. In practice these experiences are in agreement with those in nature conservation projects (see also Kishore, 1992; Redmond-Cooper, 2000).

Unlike in the West some collections in tropical regions are still privately owned (Banerjee, 1997). This creates obvious problems of access and also of preservation. It is not an easy task to convince the owners of the necessity of preventive measures (Arnoult, 2000).

2.3.1 Artefacts from the tropics

It will be clear by now that a conservator, doing his work in the tropics, encounters typical problems his colleagues in temperate zones do not have to face. These problems can be divided into those resulting from the specificity of the objects and the materials, and those arising from the tropical conditions under which they are kept and maintained.

Initially, some twenty years ago, curators and conservators began to realise that artefacts in the tropics were quite different in material, in technique and in their traditional use. Ignorance of these matters has often been disastrous. For example miniatures, which normally have a matt surface, have often been so heavily varnished as to look like oil paintings. In the past the UNESCO journal *Museum* that aims at providing information about the conservation of museum objects world-wide did this in terms of objects and materials found in the West (Agrawal, U., 1974). Since then, more and more attention has been paid to the conservation of objects for which some of the tropical countries have become so famous (see also section on *Book and Writing Materials*). In addition, the holdings of non-western artefacts in western countries benefited greatly from this knowledge (Bennett, 1985; Tanabe, 1980).

Om Prakesh Agrawal published a book on the conservation of indigenous writing and painting materials of Southeast Asia for the International Institute for the Conservation of Museum Objects (IIC). It is still very useful for anyone working with birch bark, palm leaf, cloth paintings, paper manuscripts and paintings, and than-kas (Agrawal, 1984). In an earlier work he dealt with the same subjects and in addition lacquer, bidri ware and shadow puppets (Agrawal, 1975). The introduction into traditional customs, practices and norms in handling and conserving the artefacts is interesting in both publications. Among other things, conservators of Asian manuscripts do not always realise that one important function of temples and monasteries was to take care of the preservation of ancient manuscripts (see also Greene, 1992; Mellor, 1992; Mibach, 1992; Weersma, 1987). Technically some of the local customs for dealing with artefacts are inconsistent with current preservation views. In the 1970s the reaction to ardent devotees who adorn museum sculptures of gods with ointments and garlands was still negative. Curators were advised to order their guards to check this practice (Baxi, 1974a). But the attitude of museum staff towards local customs has changed over the years (see Barclay et al., 1988). These days the prevailing opinion in museum studies is that indigenous populations have the right to perform their rituals around artefacts taken from them a long time ago and now housed in a museum environment (see Nieç, 1998). We live in a time when people claim their rights from governments. States are forced to return land, legal rights to artefacts are disputed and large groups of people are compensated for damage inflicted on them in the past. These discussions will affect undoubtedly preservation science sooner or later (also see Mulongo, 1992).

2.3.2 Climatic problems

The complete range of ill effects caused by heavy tropical climatic conditions on artefacts is a subject that has only very recently claimed the attention of a larger audience in the world of conservation. Until now no companion, guide, manual or reference book could be found exclusively dedicated to the typical problems a conservator encounters in the tropics. Indeed, a number of articles appeared on certain collections or part of collections, or very isolated typical problems, but an overall work has still to come. In the 1990s Agrawal published a more general work on preservation. It was prepared with the aim of providing information in a simple language so that the principles of preservation could be followed by the workers in more than 400 Indian museums. Regrettably the author did not pay much attention to the adverse effects of the Indian climate on the artefacts (Agrawal, 1993).

2.3.3 Lamination

There is much debate about one book and paper preservation technology in particular: lamination. This subject deserves our special attention as lamination is often seen in conservation labs in developing countries while in most western countries it has been banned, after much discussion. A distinction needs to be made between archival lamination and ‘office’ lamination. But it remains true that even archival lamination is not a good choice of treatment for many papers.

Basically, it consists of sandwiching a document between two sheets of supporting materials. It is regularly identified with a technique of inserting a document between two sheets of plastic material. An American archivist W.J. Barrow invented this method some 60 years ago. Today there are many other hot sealing devices which can be adopted for archive use. They were developed to reduce the high cost of the machine and also to reduce the high temperature required for lamination (Karim, 1988).

As early as 1947 the new lamination process was reviewed in the Indian Archives (Chakravorti, 1947). By the 1960s lamination was already seen as a partial solution to paper conservation problems. Yet, Kathpalia pays a lot of attention to all kinds of lamination processes. He explains the hot-sealing method with plastics as well as tissue paper (Kathpalia, 1966).

In the main, lamination with cellulose acetate film as thermoplastic adhesive has been banned. At the very least the cellulose acetate film has been replaced by polyethylene film. Cellulose acetate lamination is not a legitimate preservation method anymore, its reputation having suffered from the days when it was overdone and used inappropriately. Many institutions gave it up when the Library of Congress dropped lamination in favour of encapsulation in the early 1970s (McCrady, 1992).

Today most conservators prefer cold lamination above hot lamination, because there are too many disadvantages to hot lamination. For one thing, it is a rigid method i.e. it is the same for each document (Karim, 1988). For another it is hard to reverse. The quality of materials used is of critical importance. Meanwhile several delamination projects have been started to restore the documents that were badly damaged by lamination in the 1960s and 1970s.

Preservation has no all-purpose treatment. Many years ago, the term ‘lamination’ became almost synonymous with ‘preservation’. It came to be viewed as the treatment of choice, and was even applied to documents in pristine condition. Lamination is seldom appropriate to need, does not use stable materials, is radically intrusive, and difficult to reverse. Experience shows that lamination can no longer be considered a viable preservation option for papers of enduring value (Department of Archives and History, 1997).

Many of the pros and cons can be found on the CoOL-website and the Conservation Dist List.

2.3.4 Literature

An impressive body of literature has been published on preservation in temperate climate zones. The well-known bibliography up to 1972 on conservation by George Martin Cunha, and the recent follow-up, 1983-1996, from Robert Schnare give a good impression of the field of conservation (Cunha et al., 1972; Schnare et al., 2001). Schnare and his co-writers produced an imposing work of over 750 pages, which every serious conservator should acquire. Morrow and Schoenly cover the time span 1966-1979 in their conservation bibliography (Morrow et al., 1979). Jordan reviewed preservation literature from 1993-1998 (Jordan, 2000). For an Archives Preservation Resource Review see *Kaplan et al., 1991*.

The conservation environmental guidelines by the Canadian Council of Archives are essential reading for any conservation studio (Lull et al., 1995) as the chemical and physical hazards in conservation are not always known. For collection care in general see the National Park Service-website. Here it is possible to download several practical and simple leaflets like Conserve O Gram, Preservation Tech Notes, and Preservation Briefs. See also *Manning et al., 2000; Torres, 1990*.

Numerous bibliographies on preservation can be found on the internet. Look for those on the websites of SOLINET (Southeastern Library Network), NLA (National Library of Australia), Library of Congress, Grinnell College Library and SCMRE (Smithsonian Institute). The Canadian Heritage Information Network (CHIN) provides the Bibliographic and Humanities Conservation Information Network (BCIN), a huge bibliographic database with references to publications on all aspects of conservation. BCIN's contributing partners have brought together over 190,000 bibliographic records on conservation. A great deal of conservation literature is referenced, including the Art and Archaeology Technical Abstracts, technical reports, conference proceedings, journal articles, books and audio-visual and unpublished materials. The database also includes previously unavailable material from private sources, as well as new information gathered by a world-wide network of contributors. The BCIN can be accessed through the website of the Canadian Conservation Institute and is free for one month, after which you have to subscribe.

Also online is the most useful and indispensable conservation database *CoOL (Conservation OnLine)*. This project of the Preservation Department of Stanford University Libraries started in 1987 and is a full text library of conservation information, covering a wide spectrum of topics of interest to those involved with the conservation of library, archives and museum materials.

The electronic discussion forum *Conservation Dist List* is covering a wide range of preservation and conservation issues. The electronic, presently unmoderated news and discussion group *ExLibris* is of particular interest to those who mainly work with rare books and special collections. It was established in 1990 at Rutgers University and in November, 1995, moved to the University of California at Berkeley. Both lists can be accessed through the CoOL-website.

For the rest refer to the usual conservation magazines and newsletters: *Abbey Newsletter, International Preservation News, Journal of the American Institute for Conservation, Restauro, Restaurator, Studies in Conservation, The Paper Conservator*. Some of these can be consulted online.

In 1990 Claire Gerhard wrote a small bibliographical survey on preventive conservation in the tropics for her study at the Conservation Center at the New York University. She paid extra attention to conservation in African museums (Gerhard, 1990). Another recent bibliography on preservation and conservation was written by Gabriel O. Alegbeleye for the IFLA-Joint Committee on Preservation in Africa. It covers literature on paper-based materials, non-paper-based materials and buildings with an emphasis on the African continent (Alegbeleye, 2000). For a bibliography on preservation in Brazil see *Almeida, 1996*.

Early titles on the preservation in the tropics are *Anonymous, 1940, 1944a, 1952, 1954a and 1969b,; Blackie, 1930; Boustead et al., 1963; Brown, 1903 and 1908; Cundall, 1926; Davies, 1971 and 1974; Evans, 1969; Firminger, 1921; Flieder, 1966; Jantan, 1969; Kathpalia, 1966 and 1974; Kaul, 1920; Kennedy, 1959 and 1960; Kiani, 1974; Lefroy, 1909; Pacheco, 1978; Pérotin, 1969; Plumbe, 1959b and 1979; Rauschert, 1957; Savage, 1934; Shipley, 1926; Sinha, 1977; Sudborough et al., 1920; Turner, 1989; UNESCO, 1967 and 1968; Williams-Hunt, 1953.*

Other more general, regional publications or country reports on conservation in the tropics are *Aarons, 1988; Agrawal, 1974a, 1974b, 1979, 1993 and 1994c; Alegbeleye, 1985 and 1996; Al Rashid, 1974; Anonymous, 1943, 1978, 1980a, 1987, 1988a; 1994a and 1994b; Aparecida de Vries, 1992; Arfanis, 1999; Arfanis et al., 1993; Arnoult, 1989; Ashraf et al., 1980; Badu, 1999; Badgley, 1995; Bakken, 1987; Bansa, 1981; Barbáchano, 1979; Bergdahl, 1996; Bilesanmi, 1988a and 1988b; Boustead, 1964; Buchanan, 1995; Catalán Bertoni et al, 1998; Chatterjee, 1974; Chida, 1991; Clarke, 1994; Clements, 1985; Coates, 1993; Corea et al., 1992; Correia, 1998; Curtin, 1966; Dawodu, 1982; Davison, 1981; Dean, 1999a; Deshpande, 1973; d'Orleans, 1985; Dos Santos, 1996; Dosunmi, 1989; Droguet, 1988; Drewes, 2000: Duverne, 1997; Evans, 1981 and 1982; Evans, 1995; Ezennia, 1994; Faber, 1994; Fatima, 1993; Flood, 1962; Forde, 1985; Fox, 1984 and 1988; Franco et al., 1989; Gaboa, 1995; Gairola, 1971 and 1974; Giese, 1996; Gosling, 1996; Haque, 1996; Harris, 1957; Harvey, 1995; Hatch Dupree, 1999; Henchy, 1998; Iwasaki, 1974; Janposri, 1975; Jarvis, n.d.; Kabeberi, 1986; Kaiku, 1979; Kathpalia, 1982a and 1982b; Kemoni, 1996; Khan, 1992; Kibunjia, 1997; Kleitz, 1994; Kuba, 2001; Kulpanthada, 1974; Lemmon, 1990; Look, 1996; MacLean, 1993; Marsh, 1989; Matenje, 1985; Mazikana, 1992; Mbaye, 1982; McCredie et al., 1981; Morley, 1965 and 1974; Moustamindi, 1974; Munoz-Sola, 1987; Musembi, 1986 and 1999; Mwiyeriwa, 1981; National Archives of India, 1988, 1991a and 1993; Ndiaye, 1989; Newman et al., 2000; Niknam, 1992 and 1995; Nishikawa, 1977, N'jie, 1987; Noonan, 1987; Ogden, 1991; Ojeh, 1983; Ojo-Igbinoba, 1991 and 1994; Oliobi,* *1987; Onwubiko, 1991; Ormanni, 1975; Palma, 1999; Palmai, 1982; Pastoureau, 1984; Paton, 1985; Pearson, 1979 and 1993a; Perti,1987 and 1989; Petherbridge et al., 1995; Perera, 1991; Plumbe, 1987c and 1987d; Pollack, 1988; Rhodes, 1969; Ribeiro Zaher, 1999; Ricks, 1981 and 1982; Rijal, 1963; Rutimann, 1992; Salazar, 1974; Sauçois, 1976; Silva, 1991; Smith, 1996; Sulistyo et al., 1991; Souza Marder et al., 2000; Strickland, 1959; Sutaarga, 1974; Taylor, 1994; Terry González, 1996; Thurston, 1986; Tsonobe, 1986; Tunis, 1989; Unesco, 1978; Unomah, 1985; Vinas Torner, 1975; Werth, 1984; Westra, 1987; Wettasinghe, 1989 and 1994; Wheeler, 1990; Wise, 1999; Zaki et al., 1993.*

For some literature on the introduction of preservation, procedures, needs etc. in the tropics see *Alegbeleye, 1996; Bearman et al., 2000; Beck, 1999; Bergdahl et al., 1994; Cloonan, 1997a; Dean, 1997; Evans, 1992; Jalil, 1992; Kathpalia, 1978; Kivia, 1997; KraemerKoelier, 1960; Kufa, 1993 and 1997; Lyall, 1994; Perti, 1986; Plumbe, 1959a; Prajapati, 1995; Roper, 1980 and 1989; Russel, 1997; Swartzburg, 1993; UNESCO, 1989.*

2.4 Appropriate Technology

Archives in tropical areas face formidable problem. The tropical environment is very hostile to records and archives often face shortages of funds, trained personnel and training facilities. Besides, it is exceptionally difficult to obtain complex machinery or spare parts. Consequently conservation in the tropics should be deliberately oriented towards economy and low level technology; complex machinery should not be suggested unless its use cannot be avoided and the simplest acceptable solutions have been put forward (Rhys-Lewis, 1997). It will not be easy for developing countries to get the right equipment in their vicinity. For them it will be always more expensive, even if only for the extra transporation costs. The lack of a working bindery and restoration equipment was found at the Nigerian National Archives (Albada et al., 1989). Hector Montenegro from Cuba also recognised these problems. He remarked that the scarcity of economic resources and the inapplicability of much of the technology currently available, are the main causes of the problems in conservation. Creative, affordable solutions are required that address the specific regional conditions (Gerhard, 1990).

An important recommendation from the meeting on microfilm preservation in Chiang Mai in February 2000 was the need to fund research into more appropriate technologies which would recognise the realities of the climatic conditions in the region, utilise locally available materials, and establish standards which would recognise the necessities of using whatever capture techniques are at hand (Abhakorn et al., 2000; Davies, 1979). Rosenberg fully agreed and added that solutions to conservation problems must use easily accessible resources and also be appropriate to the economic situation and the culture and tradition of the region (Rosenberg, 1986).

Unfortunately, there are few technical workshops in many libraries and archives in the African developing world. Those that have a workshop, of whatever type, experience real functional difficulties. These are mostly related to minimal equipment or obsolete technical materials, chronic shortage of raw materials, and inputs, and finally maintenance (Mbaye, 1995). In quite a number of countries on other continents the situation is not very different. A significant disadvantage of educating conservation personnel abroad is that the type of equipment they have been trained with is unavailable in the motherland. Another reason to train the staff in the homeland, is that the results of a study outside the region need to be readapted to the needs of the home region. A key concept for any conservation workshop in a developing country is self-reliance (Matwale, 1995).

Quite often, despite the will to preserve, the necessary knowledge is lacking; it is not realised that by following simple precautions much can be achieved (Agrawal, 1993). Petherbridge formulates his work as a preservation consultant as follows: ‘Preservation for me is firstly technical knowledge, but that’s only a tiny fragment of the process. It’s basically a matter of managing political and economic situations. In the area of documentary preservation, it’s to do with developing a nucleus of trained specialists and a cultural infrastructure that is not dependant on outside expertise’ (Giese, 1995).

Paper has been a precious commodity for two millennia. In a changing world, there is a case for preserving information on permanent paper. Not all copies of a document need to be on permanent paper. A copy on permanent paper stored in a safe environment may preserve information for a very long time. We do not need permanent paper for every document, but we need permanent paper for all the information that will become the heritage of generations to come (Dahlø, 1998, see also Bégin et al., 2000).

In the near future certain professional groups in many rich countries will be under an obligation to use permanent papers. Frequently the quality of paper manufactured in developing countries for local use is very poor and not suitable for paper conservation (Biswas, 1992). The need for more permanent or alkaline papers is therefore even bigger in these regions (Kirkham, 1990). Several resourceful individuals and institutions took the initiative towards a more permanent local paper production. In at least three Latin American countries this idea has been put to the test. The preventive conservation projects involved are actively pursuing private industry for assistance in developing supplies of stable papers to replace poor quality papers and as substitutes for Japanese tissue and other acid-free conservation papers (Raphael, 1993).

For some time now the art of Japanese paper conservation has been very popular with western conservators. The ideas and techniques are also exported to developing countries. Yet, the Japanese papers are extremely expensive, forcing countries like Nepal, Thailand and India to use their local handmade paper for restoration purposes. These papers might not be as fine as the Japanese ones but they are certainly neutral if not a little alkaline.

In Brazil Antônio Gonçalves de Silva, chemical engineer at the National Archives, developed a conservation paper, similar to the Japanese type, from the banana tree. It has good mechanical resistance and transparency. Together with a local NGO (Non-governmental Organisation) the National Archives has undertaken a study for the construction of a plant to produce this special paper. At the same time, the aim is to create an alternative source of income to the peasants and thus minimise migration to urban areas (personal communication from Adriana Cox Hollós, Arquivo Nacional, March 2001).

A similar project is underway at the handmade paper unit of the Sri Aurobindo Ashram in Pondicherry, India. The Archives and Research Library are planning to produce a permanent paper for housing manuscripts and photographs. The mill has taken steps to make alkaline-sized, acid-free buffered papers since 2000. The unit intends to provide other institutions in India with an indigenous alternative to costly imported materials (Anonymous, 2001a). This is in agreement with one of the recommendations Pablo Diaz gave in his home country Ecuador in which he advises the conservators to organise the local manufacture of archival paper, leather, book cloth, vellum and cardboard to avoid the high cost of importing from abroad (Anonymous, 1993a). Further reading *Agrawal, 1981a; Anonymous, 1955; Banerjee, 1974; Rossman, 1935; Weber, 2000; Zizhi, 1989.*

2.5 Traditional Preservation

Many societies in tropical climatic zones had developed advanced writing systems and preservation practices long before European colonists arrived with their own record-keeping systems based on European paper, which survives badly outside temperate climates (Giese, 1995).

It has taken western scholars at least one hundred years after the first systematic collection of artefacts to recognise the individual artists in non-western art. Perhaps it will take their colleagues in archives, libraries and museums, i.e. curators and conservators, a further hundred years to discover the traditional ways of non-western preservation and its value for present preservation practices. In Africa there are plenty of examples that show that local artists are very much concerned with the durability of their creations. The lack of data about traditional preservation and restoration methods is largely a function of the general paucity of our knowledge about art technology in general. Field research should be undertaken on traditional preservation methods while they still exist (Nicklin, 1983b). Let there be no mistake about the conservation consciousness of the poorer countries.

In Bangladesh people are not very aware of the preservation of artefacts, but they do employ some methods to ensure durability while objects are in the process of being constructed. The old techniques of seasoning wood and bamboo with extracts of barks and fruits are still used in remote areas. Another way is to immerse the wood and bamboo in water just after felling. Water submersion is not exactly a seasoning process, but it protects wood logs and bamboo from insects and fungi. During water storage sugars, gums and tannins are partly leached out and as a result insect and fungi are not offered sufficient food for their survival. Most of the cellulosic artefacts are stored in the kitchen. They are hung from the roof so that they are held above the floor. The exposure of the objects to the heat and smoke prevents the attack of micro-organisms and insects.

The products of wood combustion form a thin layer of brown patina on the surface that serves as a protective coating (Jahan, 1987; Teygeler, 1993).

Jourdain, who worked as a consultant for the UNESCO in Africa, noted that fear of the total disappearance of ethnographic materials was often exaggerated in official reports. Traditionally the local population knows very well how to conserve their precious cultural heritage using simple equipment and local products of nature. She even listed several clever restoration techniques in use in the old days in Africa (Jourdain, 1990).

The art of restoring and mounting works of art on paper and silk has been practiced in the Far East for nearly two millennia. Originating first in China at the beginning of the Christian era, conservation techniques and materials quickly spread to Japan. A fifth-century Chinese writer raised points on conservation that are familiar to paper conservators today. Summarised, they are: care in handling objects, choice of correct materials for conservation, use of transmitted light for examining purposes, correct storage and vigilance against infestation, exposure to correct levels of humidity, and exclusion of sunlight (Shipping, 2000; Wills, 1987).

In order to keep the books in good condition, so-called *nanmum* wooden plates were used at the bottom and the top of the book; the whole was then tied up with cotton thread. This kind of wooden plate never changed its shape and always remained in a dry condition. Sometimes, after the rainy season, the books were dried outside on boards in the shade. If a book became wet an expert will put it in a food steamer. This will make the paper softer and it will be much easier to separate the pages when they stick together (Lin, 1999).

As during the Middle Ages in Europe, it was common practice in other parts of the world to copy texts periodically onto new traditional supports, with a bias towards preserving the information rather than the original materials themselves (Giese, 1995).

It is obvious that the study into indigenous preservation and conservation techniques lags behind techniques in developed countries. It is about time we paid more attention to this area of indigenous knowledge. When this kind of research was done in the past it was on ethnographical artefacts; hardly anything is known of the traditional ways of safeguarding the written heritage.

See also section on *Building - Traditional Building* and the sections on *Storage – Packaging – Boxes* and *Integrated Pest Management.*

For further reading see *Abhakorn, 2000; Afan, 1979; Akussah, 1991; Ali, 1979; Barclay et al., 1988; Ceesay, 1986; Chen, 1979; Coseteng, 1979; Edmonds et al., 2000; Gulik, 1958; Hendry, 1998; Hundius, 2000; Iwasaki, 1979; Kim, 1979; Kumarappa, 1971; Lee, Du Hyun 1979; Lee, Kwang Kyu 1979; Lindstrom et al., 1994; Nair, 1993a; National Park Service, 1993; Nicklin, 1978 and 1983; N'Gele, 1984; Nilvilai et al., 1995; Ojeh, 1984; Rodriguea et al., 1990; Samidi et al., 1993; Viñas, et al., 1988; Waheed, 1993; Wills, 1987; Yatim, 1979; Zhou Bao Zhong et al., 1988.*

3.1 Books

Repositories of cultural heritage in the tropics generally face more problems than their counterparts in milder climate zones. In addition some of their holdings face specific problems because of the extraordinary nature of the writing materials or binding. Different regions have their own typical writing and manuscript traditions, often heavily influenced by religious beliefs and customs. If we want to conserve or restore such typical manuscripts we need to understand these traditions. We must show respect to the (former) owner and his beliefs, and contribute to the integrity of the object. These are the ethics of safeguarding cultural heritage both for the curator and the conservator. Besides, copying in some cultures has been the traditional way of dealing with the deterioration of manuscripts until very recently. For some of the current owners the idea of preserving this cultural heritage represents a totally new way of thinking.

3.1.1 Manuscripts

Many things can be said and indeed have been said on the production of manuscripts all over the world. Firstly, let us not forget that most major literary cultures of the world have emerged from the tropics (Giesse, 1995).

Useful knowledge about non-western manuscripts has been collected by scholars of several disciplines including codicology, study of language, study of literature, study of bookbinding, art history, and conservation science. A good example of a regional language and literature introduction is *South-East Asia languages and literatures: a select guide* (Herbert et al., 1988). This guide was conceived by members of the South-East Asia Library Group, a UK based group of librarians and scholars with specialist interests in the region. They felt there was a need for a concise introduction to the history, major languages, scripts, dating systems, manuscripts, and literary genres of Southeast Asia. Although almost 15 years old it is still a very useful introduction.

A project also very worthy of note is the International Dunhuang Project (IDP). It was established in 1993 following a meeting of conservators from all over the world to promote the study and preservation of manuscripts and printed documents from Dunhuang and other Central Asian sites through international cooperation. The IDP has an attractive and useful website including an interactive web database. This page gives access to information on over 20,000 manuscripts and printed documents from Central Asia in the British Library collection. The IDP has wide links with those involved in computer development in related fields and with scientists. The project produces a newsletter, which is available online, and holds a regular conference (Barnard, 1995 and 1996; Brovenko, 1996; Cohen, 1996 and 1998; Lawson, 1996; Menshikov, 1996; Petrosyan, 1996; Raschmann, 1996; Singh, 1996; Thompson, 1996; Weisheng, 1996; Whitfield, 1996).

Al-Furqan Islamic Heritage Foundation is another institution worth mentioning. Its goal is to save and preserve Islamic manuscripts. It wants to make this enormous treasure of intellectual and scholarly heritage in Islam available to the world through conducting a world-wide survey of all libraries with Islamic manuscripts; to study and catalogue collections of Islamic manuscripts that have never been catalogued; to document (imaging) Islamic manuscripts, using the best available technological means; to edit and publish a wide selection of important manuscripts. Since 1998 they have irregularly published the magazine *Mansurat al-Furqan.* During the third conference in London, in 1995 on *Preservation and Conservation of Islamic Manuscripts* the participants unanimously decided to support the foundation of the *Association for the Preservation of Islamic Materials* (Cooper, 1992; Dutton, 1995; Ibish et al., 1996; Teygeler, 1997).

Numerous catalogues are very helpful sources on particular non-western manuscript tradition, as well as many exhibition catalogues such as:

- the British Library catalogues;
- the German series *Verzeichnis der orientalischen Handschriften in Deutschland* by W.Voigt (Franz Steiner Verlag, Wiesbaden);
- the Chester Beatty Library catalogues (Dublin, Ireland);
- the Danish series *Catalogue of Oriental manuscripts, xylographs etc. in Danish collections* by the Royal Library (Copenhagen, Denmark).

3.1.2 Printed Books

Since the 19th century more and more printed materials have been produced. Unfortunately most of these were printed on poor quality paper with high acid content (Harris, 1956; Lan, 1990). *The spread of printing* by Clair is an interesting series of monographs on printing outside Europe. It covers most of Asia but also Latin America and Africa (Clair, 1969). For more specifics on printing in the Americas see *Oswald, 1968.* The *Gutenberg Jahrbuch 1988* is totally dedicated to the UNESCO symposium on early printing in Asia, mainly Korea (Ruppel, 1988).

An indispensable source of information is the *Annual Bibliography of the History of the Book and Libraries* (ABHB). The ABHB is the current international bibliography in the field of book and library history. It records all publications of scholarly value, written from an historical point of view. This may include monographs, articles and reviews, dealing with the history of the printed book, its arts, crafts, techniques and equipment, and its economic, social and cultural environment involved in its production, distribution, preservation and description. More specifically, ABHB contains information on the history of printing and publishing, papermaking, bookbinding, book illustration, typedesign and type founding, bibliophily and book collecting, libraries and scholars. Approximately 30 countries co-operate in this project. It contains books and articles, and has been published since 1971. The editorial office has been located at the Koninklijke Bibliotheek (KB), the National Library of the Netherlands since1990, where from volume 20, 1989, the ABHB has been accessible online at the premises of the KB. Other impressive bibliographies of a more general nature are the works on Islamic culture by J.D. Pearson (Pearson, 1958, 1966, 1971, 1975 and 1979). For Indonesia the annotated bibliography of bibliographies from Kemp is a must (Kemp, 1990).

It is not our intention to list all possible non-western traditions of writing and printing, even if it were feasible. We merely want to give an impression, albeit arbitrary, of the vast literature on some of those traditions. True, for some regions and cultures more publications have appeared than others. This was because not all cultures were initially literate and consequently did not develop a manuscript tradition. Countries where oral traditions and practices prevail over writing and documentation, have little or no archival experience (Fakhfakh, 1995). Most of these cultures took to writing, however, during the colonial eras.

For more literature on writing and printing see:
General: Diringer, 1955 and 1982; Plumbe, 1961b; Vervliet, 1973
Africa: Arnoult, 2000; Glinga, 1982; Hunwick et al., 1994 and 1995; Marree, 1985; Mommersteeg, 1991; Munthe, 1982; Omoerha, 1973; Ryo, 1989; Toussaint, 1969; Wilks, 1978; (for Northern Africa see Middle East)
Central Asia: Cohen, 1998; Gansukh, 1997; Nebesky-Wojkowitz, 1949; Whitfield, 1996
East Asia: Atwood, 1989; Binh, 1992; Carter, 1955; Edgren, 1984; Kornicki, 1998; Lee, 1997; Liu Guojun et al., 1985; Needham, 1974; Tsien, 1962 and 1985; Twichett, 1994
South Asia: Agrawal, 1972b and 1982; Bisht, 1974; Das, 1987; Guy, 1982; Losty, 1982; Richard et al., 1997; Usmani, 1986
Southeast Asia: Abhakorn, 2000; Agrawal, 1984; Behrend et al., 1993; Behrend, 1993; Choulean, 1992; Coedès, 1924; Dean, 1990; Gallop, 1991; Gallop et al., 1991; Ginarsa, 1975 and 1976; Guy, 1982; Hinzler, 1993; Hooijkaas, 1972; Hoop, 1940; Hundius, 2000; Jones, 1993; Khine, 1986; Kumar et al., 1996; Kuntara, 1993; Macknight et al., 1992; Marrison, 1992; Maung Wun, 1950; Ming, 1992; Meij, 1992; Molen, 1993; Mu'jizah, 1992; Mulyadi, 1992; Noegraha, 1992; Postma, 1992; Pudjiastuti, 1992; Raghavan, 1979; Rubenstein, 1992; Rukmi, 1992; Singer, 1993; Sudewa, 1992; Sukanda-Tessier, 1992; Teygeler, 1995; Tol, 1993; Quigly, 1956; Velder, 1961
Middle East: Abid et al., 1993; Arnold, 1929: Avi-Yonah, 1973; Baker, 1991b; Beit-Arié, 1992; Chabbouh, 1995a and 1995b; Cooper, 1992; Dachs, 1982; Déroche, 2000; Déroche et al., 1990; Déroche et al., 1997; Dutton, 1995; Hussein, 1970; Khan, 1995; Maggan et al., 1991 and 1995; Pedersen, 1984; Safadi, 1972; Seguin, 1983; Stein, 1997
Latin America: Berger, 1998; Oswald, 1968; Pagden, 1972; Riese, 1988; Spinden, 1933; Torre Villar, 1970

3.1.3 Bindings

Within the literature on non-western manuscript traditions the non-western bookbindings (and their conservation) occupy a minor place. Nevertheless some literature has been published, especially on Arabic and Islamic bindings.

Because of desertification and neglect the ancient Mauritanian libraries of manuscripts, mostly privately owned, are in great danger of disappearing. A rescue operation has been underway since 1966 and continues till this day (Arnoult, 2000).

Holdings of the State Central Library of Mongolia house over one million sutras from 11th century onwards, printed and written. Those written on non-western paper and with non-paper writing materials need extra care. The main problem is to fight the dust and low relative humidity, which is a real threat in Mongolia’s dry climate (Gansukh, 1997).

In contrast to the experiences in Mongolia the National Library of Korea discovered that documents written or printed on western paper from the late 19th century to the present day face a serious preservation problem. The old books made of indigenous mulberry paper were specially treated with water and are less affected by external environmental change (Lee, 1997).

For more literature on bindings see:
China: Lee, 1929; Martinique, 1973 and 1983; Matsuoko, 1996; Nordstrand, 1967
Ethiopia: d’Abbadie, 1963; Sergew Hable Selassie, 1981
India: Bedar, 1996; Bisht, 1974; Losty, 1982
Indonesia: Noto Soeroto, 1913; Plomp, 1992 and 1993; Stutterheim, 1929
Japan: Atwood, 1987; Kojiro Ikegami, 1986; Kornicki, 1998; Thompson, 1996
Latin America: Grover, 1988
Middle East: Arnoult, 1987; Bencherifa, 1996; Binney, 1979; Bish, 1996; Bosch, 1982; Bouchentouf, 1986; Bouchentouf et al., 1985; Boyd-Alkalay et al., 1997; Braun, 1958; Bull, 1986; Clare, 1979; Daghistani, 1995; Dreibholz, 1994 and 1996; Fischer, 1986; Gacek, 1990; Haldane, 1983; Hegazi, 1995; Ibish et al., 1996; Jacobs, 1990 and 1991; Jacobs et al., 1990a, 1990b, 1991 and 1995; James, 1980; Jarjis, 1995; Keene et al., 1980; Ketzer, 1994; Levey, 1962; Maggen et al., 1991 and 1995; Mahdi ‘Atiqi, 1995; Murad al-Rammah, 1995; Raby et al., 1993; Regemorter, 1961; Schmidt, 1997; Stankiewicz, 1996; Tanindi, 1990

3.2 Writing Materials

The urge of man to express his power of speech in some form of written word led him to discover various kinds of writing materials to suit his purpose. Nearly all processes and materials connected with writing such as printing, papermaking, vellum, parchment, pen and ink, and the art of bookbinding originated in the countries of Asia and northern Africa. For many reasons one particular writing material was favoured at any given time. The two most important being availability, determined by geography, and the stage of technological development. Some materials became available only after a certain cultural stage had been reached, involving a capacity for handling and transforming raw materials. During the long course of recorded history great human ingenuity has been applied to the problem of providing suitable writing materials, resulting in a variety of widely different, yet equally effective, solutions (Gaur, 1979).

Long before European colonists arrived with their own record-keeping systems based on European paper, many countries outside Europe had developed advanced writing systems. However, such paper does not survive well outside temperate climates. Climatically well proven systems for 'memorising' data were put aside as not suitable for 'European' administrations. In some cultures both systems cohabitated, the European one providing core data, 'facts', the indigenous one providing circumstantial evidence of some importance for understanding local traditions relating, for example, to religion or to culture, or providing other kinds of information (Hoeven et al., 1996).

Knowledge of these specific writing materials is essential for any serious conservator. According to Petherbridge one can learn a lot from other cultures, in terms of different approaches, or new ways of thinking. He does not want to restrict himself to technical solutions, but also wants to engage in historical and sociological study, and research the materials he works on (Giese, 1995).

3.2.1 Palm-leaf

In India, and the countries of Southeast Asia which came under Indian influence, palm-leaves have always been the most popular among the leaf writing materials. Large collections of palm-leaf manuscripts are in the custody of many Asian libraries, temples, monasteries, learned institutions and in Asian collections elsewhere. Usually several types of palm-leaves were used for writing, depending on date and origin, and their preparation differs from country to country. The palm-leaves could either be incised with a stylus or written on with brush and ink. The question arises whether palm-leaves lend themselves better than paper to the tropical climate (Noerlund et al., 1991).

For more literature on palm-leaf manuscripts see:
General: Hunter, 1978
India: Das et al., 1991; Diskalkar, 1979; Losty, 1982; Suri, 1947; Swarnakamal, 1975
Indonesia: Ginarsa, 1975 and 1976; Grader et al., 1941: Hinzler, 1993; Hooijkaas, 1963; Rubenstein, 1992
Thailand: Schuyler, 1908

For more on the conservation of palm-leaf manuscripts see:
Asia: Bartelt, 1975; Crowley, 1969; Curach, 1995; Dean, 1999b; Florian et al., 1992; Lawson, 1988; Samuel, 1994b; Sandy et al., 2000
India: Agrawal, 1975, 1981b, 1982a and 1984; Anonymous, 1991; Bhattacharyya, 1947a and 1947b; Bhowmik, 1966; Das, 1987; Gupta, 1974; Joshi, 1993; Kishore, 1961; Kumar, 1963; Nair, 1985; Padhi, 1974; Samuel, 1994a; Swarnakamal, 1975; Suryawanshi et al., 1992 and 1994; Swarnakamal, 1975
Indonesia: Augustini, 1994; Hooijkaas, 1972 and 1979
Myanmar: Bartelt, 1972; Raghavan, 1979
Sri Lanka: Titley, 1963

3.2.2 Bark

Another material that, like palm-leaves, needs only a moderate degree of processing is the inner bark of trees. In India two varieties have been used for writing purposes: birch bark in the northwest and aloe bark in the northeast. An interesting variation of aloe can still be found on the Indonesian island of Sumatra. A slightly different type of birch bark has been widely used by the North American Indians, in one case as a writing material. Beaten bark, so-called barkcloth or tapa, is principally known as an ethnographic textile (Bell, 1992a) but on the Indonesian island of Java and in Middle America, people used to write upon barkcloth.

For further literature on bark manuscripts and their conservation see:
General: Anonymous, 1995a; Bell, 1992a; Diskalkar, 1979; Florian et al., 1992; Gaur, 1979; Hunter, 1978
India: Agrawal, 1975 and 1984; Agrawal et al., 1981; Agrawal et al., 1984a; Agrawal et al., 1984b; Agrawal et al., 1987; Batton, 2001a and 2001b; Felliozat, 1947; Kumar, 1963; Kumar, 1988; Losty, 1982; Lyall, 1980; Majumdar et al., 1966; Rymar, 1978; Suryawanshi, 2000
Indonesia: Teygeler, 1993, 1995 and 1998; Teygeler et al., 1995
Middle America: Bell, 1992a; Bockwitz, 1949; Christensen, 1972; Godenne, 1960; Hagen, 1999; Hunter, 1927; Lenz, 1961; Rodgers Albro, 1993; Sandstrom, 1986
North America: Dewdney, 1975; Gilberg, 1986; Gilberg et al., 1983 and 1986; Hoffmann, 1998; Selick, 1987

3.2.3 Paper

Finally we come to paper, another triumph of traditional technology. Many factors led to the invention of paper. The place of origin is China, whose inhabitants were able to make excellent paper in a very short time after its invention in the 2nd century BC (Before Christ). From there it spread to the rest of East Asia and via Central Asia and the Middle East and slowly found its way to Europe which it reached eleven hundred years later. Much has been written about the paper history of Europe, and it is a subject that should be of interest to all archivists, librarians and curators working in the tropics, because much of the manuscript, printed and archival matter is on western paper.

The father of paper history is the American Dard Hunter (1883-1966). He is best known as the paper historian whose writings form the cornerstone of our knowledge about the world of handmade paper: its history, technology, and materials. In order to gather firsthand knowledge about the manufacture of paper, he travelled the world collecting tools, equipment, raw materials and paper samples. Through his Mountain House Press, he published his knowledge of world papermaking in a number of important, limited edition, handmade volumes. Some of his publications have been reprinted like the invaluable *Papermaking. The history and technique of an ancient craft*, a book that should never be absent from the bookshelves of any serious paper historian (Hunter, 1978). The other volumes are more difficult to obtain, but nevertheless form an important starting point for the study of any paper history, especially the Asian and Mexican paper history (Hunter, 1927, 1932, 1936a, 1936b, 1937, 1939, 1943, 1947). Another basic work into the study of paper is the *Dictionary and encyclopaedia of paper and papermaking with equivalents of the technical terms in French, German, Dutch, Italian, Spanish & Swedish* published by Labarre (Labarre, 1952). The first edition is from 1937, it was revised and enlarged in 1952, and it was supplemented by Loeber in 1967 (Loeber, 1967).

Compared to western paper, the study of non-western paper is a much more difficult task. The literature on this subject is difficult to find and is spread throughout various obscure magazines, journals and reports. A good aid to the study of both western and non-western paper is the bibliography by Leif. It is the first comprehensive bibliography on handmade paper, from its earliest appearance to the manufacture of paper by machine in the first half of the 19th century. Pre-paper writing materials (papyrus, vellum, parchment) are noted too, insofar as their relationship to paper is concerned. The work is provided with a subject and author index and the listings are by country. The reader has to keep in mind that many publications on paper history since 1978, western and non-western, have appeared. (Leif, 1978).

Only a few paper collections are publicly available and made accessible scientifically. The Koninklijke Bibliotheek (KB), is one of the few libraries in the world that possesses a paperhistorical collection. The foundations for this were laid in 1971 with the acquisition of an extensive private collection, consisting of literature, paper sheets and various forms of documentation. The KB-collection of decorated paper from both the East and the West is famous. In the course of time, the KB historical paper reference library has acquired considerable additions. Much attention has been paid to the completion and improvement of the indexing of the collection in the last few years, and to making the varied information sources at the department accessible to an increasing number of researchers and other interested persons. Because of this, the historical paper collection has developed into an international centre for historic paper research and documentation accessible on the internet.

The *Deutsche Buch- und Schriftmuseum*, part of the Deutsche Bibliothek in Leipzig (the National Library of Germany), is the oldest book museum in the world, founded in 1884. One of their famous study collections is the *Papierhistorische Sammlungen*, the historical paper collection, now available on the internet. It includes a watermark collection of 400,000 samples, western and non-western decorative and marbled papers, and over 600 samples of handmade and machine made papers. The specialist library contains amongst others the famous library from the Börsenverein der Deutschen Buchhändler, the Association of the German Book Exchange.

There are a couple of international organisations of interest for those who want to know more about papermaking. The most important is the International Association of Paper Historians (IPH). The IPH integrates professionals of different branches and all friends of paper within the field of paper history. It co-ordinates all interests and activities in paper history as an international specialist association co-operating with international, regional and local organisations, not only of paper historians but also of keepers of archives and libraries, conservators, art historians, specialists in books, printing and technology, associations of the paper industry, the publishing trade etc. To reach these goals, IPH publishes *Paper History* three times a year and holds an international congress every two years. One helpful tool on the IPH website is the link to various watermark databases.

The International Association of Hand Papermakers and Paper Artists (IAPMA) is dedicated to assisting all those interested in paper and to advancing traditional and contemporary ideas in the art of hand papermaking through meetings, events, publications and visual research and a documentation centre. The main objective of the association is to facilitate and encourage the international exchange of ideas and information about hand papermaking. Congresses incorporating general meetings take place bi-annually.

Hand Papermaking is a non-profit organisation dedicated to advancing traditional and contemporary ideas in the art of hand papermaking through publications and other educational formats. The primary goal of the organisation has been to provide information to a diverse international audience of paper artists, mills, dealers, historians, and conservators. They publish *Hand Papermaking* magazine twice a year and *Hand Papermaking Newsletter* four times a year.

Some publications on non-western paper are:

General: Bell, 1992b; Collings et al, 1978; Hunter, 1978
Bhutan: Yoshiro Imaeda, 1988
China: Drège, 1981; Fei Wen Tsai et al., 1997; Harders-Steinhäuser et al., 1963; Li Shu-hwa, 1969; Tsien, 1985
India: Green, 1996; Narayanswami, 1961; Soteriou, 1999; Teygeler, 2001
Japan: Barrett, 1983; Hughes, 1978; Masuda, 1985; Narita, 1954; Paireau, 1991
Madagascar: Colançon, 1921; Rantoandro, 1983
Mexico: Ackerson-Addor, 1976; Lenz, 1968
Middle East: Baker, 1991a; Bavavéas et al., 1990; Karabacek, 1991; Loveday, 2001; Wiesner, 1886 and 1887
Myanmar: Koretsky, 1991; Sindall, 1906
Nepal: Gajurel, 1994; Trier, 1972
Persia: Le Léannec-Bavavéas, 1998
Thailand: Siegenthaler, 1996
Tibet: Harders-Steinhäuser, 1969; Nebesky-Wojkowitz, 1949; Sandermann et al., 1970
Turkey: Kagitci, 1965
Vietnam: Bùi Van Vuong, 1999

4.1 Introduction

In the developing world, after the second World War, there has been an upward trend in the number of new libraries, archives and museums. A boost in building activity occurred especially in the sixties when many countries gained their long desired independence. The availability of a suitable building for archive operations must be regarded as the first prerequisite in the preservation and conservation of archive materials. It is so obvious that it tends to be overlooked: *buildings are the first line of defence* against a severe climate and various disasters, and thus the primary means of preservation of collections. Preservation should be the basic and general guide for architects and archivists planning an archive building (Buchmann, 1998). Often the building is the *only* line of defence for the majority of museums worldwide (Daniel et al., 2000).

Understanding the importance of buildings in preserving records is hardly new. The Roman architect Vitruvius, in the first century BC, describes where the library should be located in a house to catch salubrious breezes and avoid excess humidity (Banks, 1999). In nineteenth century India, the authorities started to create a network of buildings according to specific standards for the storage of district records. In the tropics the architect has to employ his full armoury of devices to combat an aggressive climate (Plumbe, 1987b). An active building programme can involve the restoration of old buildings as well as brand-new constructions, or a combination of both. It is also a pressing concern in the move towards modernisation of archives (Conté, 1996).

In some countries, even now, the condition of archives and library buildings is alarming. The National Library of Laos had until recently no permanent building and had to be moved five times in recent years. For this reason it has been impossible to organise the collections effectively. Fortunately today the situation has changed for the better (Noerlund et al., 1998). Since World War II many new library buildings have arisen in the West as proud symbols of a new era (Holdsworth, 1959).

There is much to be learned from the continual search for the ideal building which has resulted in a range of national and international standards, such as the British Standard (BS 5454) or the International Standard Organisation (ISO 11799) (Rhys-Lewis, 1999). In some countries, there is much central control over building designs. The advantage is that it can lead to the development of a central body of technical expertise about the construction of record repositories (Thomas, 1988). Yet we should not forget that the conditions and circumstances in tropical countries ask for a different approach. An archive building to be designed for harsh climatic zones demands special precautions. It has to be able to stand extreme heat and humidity, keep the sun away, offer protection against or prevent excessive mould growth, keep insects and rodents out, and be able to withstand the most horrific disaster scenario (Duchein, 1980).

That the construction of an archive is more than a building alone can be learned from the example of Burkina-Faso. Despite international funding the creation of the National Archives depended above all on the government itself, in particular the slow-moving wheels of bureaucracy. It took more than 30 years to achieve the construction of a central building, demandeding considerable perseverance (Ouedraogo, 1999).

A number of publications and guidelines on building archives has been published. Yet, archive building in tropical climates has not received much attention so far. The lack of an information base on tropical building in general is often cited as a problem (Ifidon, 1990). In 1979 UNESCO published a book on the design of archive buildings in tropical countries. It is primarily written for the archivist and architect who are both a party in the design and development of an archive building. The book is filled with technical line drawings and diagrams, and in this way the authors succeeded in explaining practical problems and their solutions very conveniently. Technology has changed rapidly in the course of the twenty years that have passed but that does not diminish the value of this lucid approach to the most common problems and the low-tech solutions. It is still a very worthwhile source for any archivist who favours a simple and sustainable design for an archive building (Bell et al., 1979).

A rudimentary RAMP study from the 1980s deals with guidelines for the techniques to be used in archive building in the tropics by comparison with building in countries in temperate climates. The authors treat the storage room, wall, floor loading, shelving, aisles and lighting successively. Emphasis is placed on economical construction and subsequent maintenance. Although most of the premises are still true today, the techniques are outdated (Benoit et al., 1987). Sometimes a chapter on building in the tropics can be found in general works on archives, e.g. Karim's book on archives administration in Bangladesh (Karim, 1988).

The publications by Michel Duchein (1980 and 1988) have been very popular in the world of archive building for a long time. In particular his *Les bâtiments et équipements d'archives* from 1966, translated into English, revised and enlarged in 1977 and 1988, grew to be the bible of the business (Chauleau, 1980). In the back of the 1988 edition a select bibliography is included. However, this book is written for the western archival situation, thus for temperate climatic zones and, in any case, the world of architecture and not the least the world of technology, have changed substantially over the years. His article from 1980 however is totally devoted to buildings in tropical climates. In this survey he is quoted several times because some of his suggestions and ideas are still very practical.

A more recent publication is the sourcebook on archival building by Ted Ling, based on 30 years experience in Australian archive building. He writes that the design, construction and management of an archive building is changing rapidly. Paradoxically, while construction has proceeded on a grand scale, very little study has actually been devoted to these buildings. What has been needed for some time is a 'How to' book which synthesises all aspects of the building of archival facilities in the generic sense. True, this publication is based on building in the western countries except for a few pages, but it is nevertheless a very practical and concise publication (Ling, 1998).

An American bibliography on the planning and design of library buildings appeared in 1990 (Dahlgren et al., 1990); an overview of 15 years archive building in the United Kingdom appeared in 1992 (Kitching, 1993). For some older European concepts see *Archivum 1957(7)*; *Bernard, 1982; Lehnbruck, 1974 and Sanchez Belda, 1964* and for the tropics see *Bhowmik, 1974; Gwam, 1966*; *Hoare, 1978; Lippsmeier, 1980 and Marshall, 1974.*

Below we will discuss the literature on some important topics that play a major part in the current discussion on building archives in the tropics. First some general literature on climate and building is looked at, in which it becomes clear that the tropics are not just one climatic zone. In moving to new premises the archivist is often confronted with the choice of adapting an old building to become an acceptable archive, or building a new archive. It is important that the architect and archivist work together and take preservation as a starting point. Any modern archive building has to fulfil the many demands dictated by a modern sustainable society, be it east or west. Passive climate control and climate responsive buildings are key concepts in sustainable building, an integrated building view that frequently corresponds with to the principles of a number of traditional building styles. The location of the building is crucial. One possibility is to build underground, though humidity remains a problem. In the construction of the archive safeguards can be built in to overcome problems of high temperatures and high relative humidity. A lot can be done by use of proper building materials, the correct positioning of doors and windows and the appropriate construction of the roof.

4.2 Climate and Building

Western cultures have inherited many stereotyped and colonial ideas about the tropics. Not all these regions are hot, humid and underdeveloped in their capacity to preserve their rich documentary heritage, as was often believed. In fact, the climatic range is diverse and the tropics contain some of the world's most venerable and modern libraries and archives (Giese, 1995). Nevertheless, the complexities of tropical climates with high temperature and soaring humidity present major problems for any building, including archive buildings. The ground is primarily dry and dusty and foundations become compromised in these conditions. There is also a great variety of insect pests that destroy the fabric of the building. This situation is often exacerbated by poor maintenance, with many opportunities for penetrating the building by larger animals such as rats and mice. Biodeterioration is very much a concern with mould growths resulting from flooding and bad air circulation (Rhys-Lewis, 1999).

In tropical zones the *mean* annual temperature is not as important as the annual temperature *range* which gives an indication of the variation throughout the year. Even more important is the daily range. For example, temperatures on stone surfaces of the Borobodur temple complex in Indonesia were recorded as having risen from 25 ºC to 45 ºC in 4 hours to a depth of approximately 5 cm. The same applies to relative humidity. The distribution of rain is an important factor and it is the daily fluctuation that counts for conservators. During the day the maximum levels of relative humidity occur a little before sunrise and the minimum levels in the early evening, approximately the reverse of temperature. Naturally there are other factors involved such as groundwater level and marine environment. It is this large and frequent variation in temperature and relative humidity that causes so many problems in our efforts to safeguard our cultural property (Davison, 1981).

The main climatic factors affecting human comfort and relevant to construction are (Gut et al., 1993):

- air temperature, its extremes and the difference between day and night, and between summer and winter;
- humidity and precipitation;
- incoming and outgoing radiation, the influence of the sky condition, air movements and winds.

For further reading on building in the different tropical climates see *Agrawal et al., 1974; Baxi, 1974b; Chan, 1978; Fry et al., 1956 and 1964* (perhaps somewhat outdated); *Fullerton, 1979; Holdsworth, 1974; Konya, 1984; Moreno, 1991; Overseas Division of the Building Research Establishment, 1980; Saini, 1980; Thomson, 1974.* For old bibliographies see *Anonymous, 1953 and 1954b; National Research Council, 1953.*

4.3 New Building

In the planning and construction of an archive building both archivist and architect should take preservation as a starting point. It has an important and decisive impact on the building of the stacks, the laboratories, the areas for the public and the offices. Climatic conditions are of special importance (Buchmann, 1998). In 1959 Plumbe noticed optimistically that cooperation between architect and librarian was not so much a recognisable trend as normal practice (Plumbe, 1959a). Nonetheless, according to Holdsworth in the same journal, architects were a rare phenomenon in many developing countries. It is the local public works departments, largely under the direction of civil engineers, which have been the principal building organisations (Holdsworth, 1959). Apparently some decades later the situation had not improved much (Havard-Williams et al., 1987).

It is shocking that even in a very recent publication of the IFLA Section on Library Buildings and Equipment so little attention is paid to preservation through building construction and design; only two out of the 16 speakers on the seminar broached preservation issues (Bisbrouck et al., 1999). At the next IFLA meeting in Shanghai it became clear that the libraries were increasingly people-orientated instead of book-orientated, and still there were no extensive accounts of building as a first line of defence. The designs are predominantly functional (Bisbrouck, 2001). M. Amosu raised the point that in Sub-Saharan Africa it is rare for any institution to start with all newly built edifices and the libraries in particular are often housed in temporary quarters. All the same, she considered this an advantage because most library staff involved in the planning had personally suffered the discomfort of inadequate space and noise (Amosu, 1974).

When planning the first permanent building for the Nigerian National Archives at Ibadan preliminary inquiries were made in the USA, Great Britain and Rhodesia about the basic features and requirements of a modern archive building. The important fact revealed by these investigations was that the proposed building would be the first of its type in tropical Africa. It was decided that its ultimate shape and structure would be determined by local considerations, a situation European and North American architects had not encountered previously (Gwam, 1963).

Prior to 1920, considerable weight was given to architectural effect in library construction and minor attention to functional requirements. Monumental buildings were constructed which were architecturally impressive, but were not well suited to their purpose as libraries. Today the emphasis has changed; there is a growing realisation that, to agree with Le Corbusier, form follows function (Nwamefor, 1975).

Nevertheless, G. Kumar maintains that in India most libraries continue to be constructed following monumental designs, with high ceilings and vast foyers (Kumar, 1981). This is based on the 19th century European idea of the museum being 'the place of the muses' and therefore the building has to have a specific design (Myles, 1976).

Few archivists have the luxury of being able to specify the structure of their building. If they do, several points have to be taken into account: location (away from obvious hazards), as high a thermal mass as possible (less environmental control inside), pitched or sloping roof (better rainwater drainage and reduction of leaks) (MacKenzie, 1996).

Another main problem in developing countries is the absence of national standards for archive buildings or the insufficient observance of such standards (Ifidon, 1990; Nwafor, 1980). G. Kumar wonders why so little of national cultures can be recognised in the new buildings. For example the Indian love of courtyards could be carried over into libraries, and the preference for sitting cross-legged or in a reclining position should be considered in choosing the furniture (Kumar, 1981). In Africa students have hardly any study spaces at home, so African libraries will require a larger number of such spaces than is needed in western countries (Amosu, 1974).

Building dwellings above the ground, on piles, is a widespread custom in many tropical countries. This practice has many advantages: it protects the ground floor from the wet or humid soil, it is a first protection against floods and offers, in the case of concrete piles with anti-termite shields, a good defence against termites and other crawling insects (Duchein, 1980; Karim, 1988). To prevent, or at least reduce termite attack floors should be made of concrete, metal strips should be inserted in the joints, and the pipes and concrete piles should have metal caps. The best means of ensuring the protection of library materials against termite infestation is to prevent the insects gaining access to them (Plumbe, 1987c).

The building's drainage system should be designed to remove water run-off quickly. Given the huge volumes of water involved this can be a major feat. Circular drainage pits, placed at regular intervals along the longitudinal sides, can be a solution. These are filled with rocks, which reduce the velocity of the water's impact, and collect run-off water away from the property as quickly as possible (Ling, 1998).

Tropical storms frequently cause lightning strikes. To avoid damage the new building must have a lightning rod installed on the roof. This common method involves an earthing system designed to dissipate any potential damage that lightning may cause. The lightning can strike several hundred meters away from the building and the effects can still be felt. If it hits a power line, the surge will travel along the line and into the electrical system of the building and may cause considerable damage. The electrical system needs protection in the form of a surge diverter but regrettably the system is not foolproof. At best, the risks can be reduced or the damage minimised (Ling, 1998).

Galleries, balconies and verandas are a common sight in hot and humid countries. They are very practical in keeping the sun away from the windows or outer walls (Duchein, 1980). The construction of porches will also shield arriving goods as well as visitors from the rain and the sun (Plumbe, 1987b).

The surface area of the building should be kept as low as possible to minimise heat gain or loss; this precludes the use of tower blocks that have a relatively high surface area in comparison to their volume (Thomas, 1987). In the last decade or two there has been a growing tendency in the west to construct highrise archive buildings. Because of fast-moving lifts and elevators vertical movements are no lonher curtailed. But there is no point in building archive towers as a matter of course; it is a question of balancing several factors (Duchein, 1988).

In India hollow walls, double walls or false inner walls were still recommended in 1975 as it was recognized that they often act as effective barriers against the penetration of humidity and dampness from the outside (Swarnakamal, 1975). In Canada a new approach was developed: the construction of a building in a building. The idea is that areas involving people are located as close to the outer shell of the building as possible and the storage area near the central heart of the building. By this method, the storage areas are further protected from external climatic variations. Consequently the facility will be bigger and more expensive (Ling, 1998).

For building repositories in the tropics see *Badioze Zaman, 1989; Bisbrouck, 2001; Faye, 1982c; Mahmud et al., 1985* and for older concepts see *Drew, 1968; Feilden, 1979; Rousset de Pina, 1961; Toishi, 1974 and 1979.* For general literature on building in the tropics see *Blight, 1988; Dequeker et al., 1992; Kukreja, 1978; Lippsmeier, 1980; Salmon, 1999; Schroeder, 1989; Waal, 1993* and for older concepts see *Danby, 1963; Foyle, 1954; Koenigsberger et al., 1974; Royal Tropical Institute, 1962.*

4.4 Sustainable Building

Over the past decade, sustainable development has emerged as the favoured way of responding to the continuing degradation of the global environment. The approach was launched into the international political arena by the World Commission on Environment and Development (WCED), chaired by Norwegian premier Gro Harlem Brundtland in 1987, which defined it as *'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'* (Brundtland, 1987). For the WCED, sustainable development includes two key concepts. First, the concept of needs, in particular the essential needs of the world's poor, 'to which overriding priority should be given' and second, the idea of 'limits' to the environment's ability to meet present and future needs, imposed by the state of technology and social organisation.

To translate Brundtland's report into action the United Nations Conference on Environment and Development (UNCED) organised an Earth Summit in Rio de Janeiro in 1992. One result was the Agenda 21 action plan, which provided for the first time an international agreement on the practical implications of sustainable development for cross-cutting issues such as trade, consumption and population growth, and sectoral issues among which architecture was included. In 2002 the next United Nations World Summit on Sustainable Development (Rio+10) Earth Summit will be organized. This ten-year review of the Earth Summit Agreements in 2002 will be a major impetus to catalyse collaborative action to implement sustainable development more effectively (see National Councils for Sustainable Development NCSD website).

Since 1992, an array of local and national strategies have been designed to tailor these recommendations to specific conditions facing different communities across the world. One particular aspect has to be pointed out in this context: the steadily increasing energy consumption, and building designs or architecture, urban design and planning not adapted to local climatic circumstances,.

Too often climatic factors are neglected in construction because they are not of immediate interest and concern to the building industry, builders, designers, developers and owners. This is true not only for structures in hot climate zones, but also for those in temperate and cold climate zones. With the input of sufficient energy almost everything seems possible but present construction trends in tropical and subtropical regions still show little awareness about energy conservation. The widely applied international concrete box and iron sheet style of ubiquitous buildings is not adapted to local climatic conditions and hence its worldwide influence is questionable (Gut et al., 1993).

Building cannot escape the far-reaching consequences of this concept in a society that is moving gradually towards sustainability. This is proven by the fact that the Royal Institute of British Architects (RIBA) has included ecological sustainability on the curriculum for all the RIBA recognised courses (Smith, 2001). One of the new publications that outlines the future of the sustainability debate in architecture is *Taking Shape* by Susannah Hagan. By focusing on the impact of the new theories of sustainable technology and new materials in architecture, Hagan moves the discourse and practice of environmental sustainability within architecture towards a greater degree of awareness of both its cultural significance and cultural potential (Hagan, 2001).

Hans-Peter Jost and Jutta Schwarz discuss how to go about constructing archive buildings in line with the main principles of ecologically sound construction (Jost et al., 1996). Considerations include the choice of the site, external arrangements, optimum use of energy, choice of materials, ensuring a long life for a building, ease of maintenance, and stabilisation of building waste. However, the article only deals with building in the West.

Recently an interesting study was published in the well-known Butterworth's Series in Conservation and Museology on the ecology of building materials. It gives a comprehensive understanding of ecology in building and provides vital technological information that allows the architect to put ideas of sustainability into practice (Berge, 2000). In the same series an ecological and environmentally responsible guide to the preservation of historic timber structures has also appeared, founded on respect for traditional crafts and building techniques. It illustrates the new, universally applicable approach to preservation based on the Principles for the Preservation of Historic Timber Structures, adopted by the International Wood Committee of ICOMOS (The International Council on Monuments and Sites). Considerations of appropriate technology, preservation of old-growth forests, and redevelopment of traditional craft skills are central to its arguments (Larsen et al., 2000, see also Schreckenbach, 1982; Sierig, 1991c).

The green awareness became especially popular when the cost for archive building rose (Rombauts, 1996). In Australia today there is a much greater understanding of a building’s total structural integrity than ever before. Archivists now think in terms of a building’s capacity for sustaining environmental conditions, not just creating them. They think of the entire building structure e.g. wall, roof, and floor as a means of aiding this process (Ling, 1998). Archivists in charge of planning new buildings do not generally accept the concept of achieving a stable climate in the stacks by means of construction without energy consuming electric devices. Somehow the idea of sustainable archive building did not really catch on in the USA (Banks, 1999).

The study by Paul Gut and Dieter Ackerknecht: *Climate responsive building* is a very comprehensive approach, dealing particularly with building in tropical climate zones, published by the Swiss Centre for Development Cooperation in Technology and Management (SKAT). Climate responsive building is a possible alternative to climatic non-adapted building. It involves the application of soft measures and natural means to reduce energy consumption by design, construction and materials appropriate for a specific climate. This also has positive consequences in terms of economy as well as in terms of proper use of local resources. Improvements can be achieved when buildings are conceived in an integrated approach. This includes the settlement pattern and urban forms and the selection of the site according to microclimatic criteria. The shape and type of buildings and their orientation, the integration of suitable vegetation and the arrangement of the external and internal space require careful consideration. The correct use of building materials, designs of openings and their shading, natural cooling, passive solar heating and the well-aimed utilisation of prevailing winds for ventilation are important supporting elements.

In general, the SKAT publication provides the necessary information for the planning and construction of buildings in tropical and subtropical regions with respect to natural climate control by passive methods (i.e. without energy consuming appliances). In the main, low-cost and appropriate concepts are envisaged. A major part of the book is dedicated to the nine experiments and simulations Gut and Ackerknecht conducted in diverse climatic zones. The Appendix contains the physical data required to assess the properties of the main building materials and other useful lists such as an extensive bibliography (166 titles), solar ecliptic charts for tropical and subtropical regions and conversion factors.

According to Gut the main points to take into consideration when designing a climate responsive building are (Gut et al., 1993):

- minimise heat gain during daytime and maximise heat loss at night in hot seasons, and reverse in cold seasons;
- minimise internal heat gain in the hot seasons;
- select the site according to microclimatic criteria;

- optimise the building structure (especially regarding thermal storage and time lag);
- control solar radiation;
- regulate air circulation.

4.4.1 Passive Climate Control

The concept of passive climate control is completely in line with the notion of sustainable building. It is an alternative to a mechanical air-conditioning system and as such is an essential part of sustainable building. Passive climate control implies that the repository is built and arranged in such a way that the thermal and hygroscopic properties of the building and its contents create a good stable indoor climate. It concentrates on building physics and ensures that the temperature and relative humidity stay within acceptable ranges. For most, passive climate control is a design principle where it is important for the engineer to be aware of how the building is used. At the same time it is important for the user to be aware of any activities that could possibly have an unintended and inappropriate effect on the indoor climate (Christoffersen, 1995).

It is clear from the recent history of the construction of repositories in tropical climate zones, whether archive, library or museum that the repositories play a major part in passive climate control. It is especially important in tropical climates that buildings are designed or retrofitted to minimise moisture problems (Daniel et al., 2000). It is regrettable that still too little research work has been undertaken to develop passive climate control where the design of the building ensures a stable environment (Lyall, 1997).

Lars Christofferson conducted a remarkable Ph.D. research and development project on passive climate controlled repositories. He developed a resource saving concept for the establishment of a suitable climate and introduced ZEPHYR Climate Controlled Repositories together with the idea of sustainable storage. Although he based his study on storage facilities in Northern Europe it is still worthwhile reading for those building in the tropics (Christofferson, 1995).

The first archive building in Africa is an interesting early example of passive climate control. In the design of the new building of the National Archives of Nigeria in 1958 many practical and cheap solutions were found to control heat and humidity. Complete ventilation is provided on all floors with standard adjustable grain-glassed louvered windows with steel bars on the inside for protection against burglars. For the same reason the wings of the building have been made long and narrow with many doors and windows placed opposite each other. Sun protection for the external walls is provided by the vertical fins between each window and by horizontal sun-breakers immediately above the windows (Gwam, 1966).

Channelling the wind can also provide ventilation. For this purpose windscoops or special screens are installed on roofs to divert the wind to channels which reach the rooms. This technique has been used in certain very hot and dry parts of India for centuries. Normally one windscoop is provided for each room and in multi-storeyed buildings the channels reach all the way down. This type of ventilation is only possible if the wind blows regularly in the same direction (Agrawal, 1974).

A particular method of preventing solar gain has been employed in the 1982 archive building of Botswana, Africa. Here, earth berms are constructed to the underside of windows encasing the first and second floors. The berms have a roof structure that forms a vented air space between itself and the building fabric, thus preventing direct solar and radiant heat gain (Lekaukau et al., 1986).

In Cologne, Germany the system of 'natural air-conditioning', a form of passive building, is applied to about 10,000 square meters. It has proven to be an effective method for stabilising temperature and humidity within a range acceptable for paper records. The whole strong-room is surrounded by air above ground; the air can pass up under the facade and through the space between the roof and the ceiling. With this construction the room is insulated as much as possible against the outdoor climate and its changes (Buchmann, 1998; Stehkämper, 1988). In South Africa the box within a box-idea is explored in a subterranean construction (Harris, 1993; Rowoldt, 1993 and 1994). An up-date on this topic appeared in 1992. The author is surprised by the lack of serious discussion on this 'Kölner-model' and discusses other experiences in the German-speaking countries (Stein, 1992). International comparisons show that builders generally use structures having a small surface area with heavily insulated walls to achieve a stable internal environment (Thomas, 1988).

That sustainable architecture can be established with very little means, including financial, is proven by Laurie Baker who, during the course of 30 years, built over 26 buildings. Among others he was responsible for the construction of the Library of the Centre for Development Studies at Trivandrum, Kerala. The eight-story building was built with exposed brick without cement. It is a cool building using natural ventilation and light (Hochschild, 2000; Kremp, 2001).

For more details on construction materials see the section on C*onstruction* below and for an older state of the art study on passive cooling see *King, 1984*, for a later case study see *Rosenlund, 1993.* For further reading on passive climate control see *Adamson et al., 1993a and 1993b; Allard, 1998; Anonymous, 1982a, 1982b, 1985b and 1997; Ayres et al., 1988; Bahadori, 1979; Baker, 1987; Bansal et al., 1994; Cofaigh Eoin et al., 1996; Dodd et al., 1986; Doswald, 1977; Edwards, 1994; Fischer, 1984; Fitzgerald, E. et al., 1999; Holm, 1983; Padfield et al., 1990; Roaf, 2001; Rosenlund, 1989; Rosenlund et al., 1997; Sacré et al., 1992; Swartzburg et al., 1991; Slessor et al., 1997; Yang et al., 2000.*

On sustainable building in general see *Clark, 1990; Edwards, 1999; King, 1993; Kokusen, 1998; Melet, 1999; Piano, 1998; Ray-Jones et al., 2000; Steele, 1997; Vale et al., 1991; Yeang, 1999.*

For a bibliography on passive solar systems see *Anonymous, 1989a,* see also *Rosalund, 1989 and Stulz, 1980.* Also check the SKAT website.

4.5 Traditional Building

The local population usually knows how to adapt to harsh tropical climate conditions. One practical way to manage these climatic effects is found in the development of traditional building structures. For each of the different climate zones a suitable form of traditional building can be found, but for various reasons, new buildings and constructions are often not adapted to the local context. As a consequence, indigenous know-how and experience is lost in many areas (Gut et al., 1993). Traditional housing can be of great interest to designers of archive buildings particularly in respect of passive climate control. Sandra Rowoldt put it very clearly when she advised on domestic architecture and how it adapts to the regional climate, and then looked at most institutional buildings and how that adaptation is generally ignored (Rowoldt, 1993). Agrawal agreed when he wrote that traditional architecture is very much influenced by the climate. Analysis of traditional measures to counterbalance the extreme climate provides some solutions which can be adapted to the present conditions (Agrawal, 1974).

It has been established that buildings made by the indigenous inhabitants sustain less damage during natural disasters than those built by recent residents (see section on *Disaster Preparedness*). Purely traditional solutions, however, also assume a continuity of lifestyles and a kind of work, which seems unlikely to occur in many regions. A combination of traditional knowledge and advanced technology may therefore be necessary (Gut et al., 1993).

Some unique and excellent construction methods have been developed in Japan. In order to fight mure, i.e. a climatic condition arising from a combination of high temperature, high humidity and lack of air circulation, the Japanese constructed gable roofs, traditional soil walls and raised floors in the past. Gable roofs keep sun light out, long eaves give shade to the walls and protect them from rain, and woods and soils are materials which absorb and give off moisture (Kathpalia, 1973; Kenjo, 1997 and 2000).

The Shoso-in, imperial repository, in Nara where the 1200 year old T'dai-ji treasure is kept also reflects the traditional Japanese understanding of how to preserve records (Banks, 1999). As still can be seen today in many Southeast Asian temple libraries, these well-shaded, tile-roofed wooden structures are raised about 2.5 meters off the ground to provide maximum air circulation (Noerlund et al., 1998). One explanation for the success of the protection offered by the Shoso-in is that the log-cabin style construction of the building allows the individual wooden elements to expand and contract with changes in humidity, thereby regulating the environment of the interior chambers by sealing and opening the wall according to the changes in the weather (Wills, 1987).

Many medieval Khmer religious complexes surviving in Cambodia and Thailand contain stone library buildings. In Pagan, a medieval capital of Burma, a twelfth-century building still survives with a deep central chamber buffered against atmospheric change where precious Buddhist manuscripts were kept in protective chests (Giese, 1995).

Sometimes very simple but effective solutions are found to ameliorate the worst effects. The strong room of one of the oldest Buddhist temples in Korea, Haeinsa, was built in 1488 and holds the complete collection of Buddhist sutras carved in wood. In order to improve the preservation of the books they designed the windows on the north and south side of the wall. This way the windows opposite each other stimulate the current of air and thereby control the temperature and the relative humidity (Lee, 1997). An archive building in Hanoi, Vietnam, which is an old French colonial building built as a repository, has open sections in the floors below each block of shelving to aid air circulation. In the roof, the floor has been covered in sand to act as insulation against the transfer of heat (Rhys-Lewis, 1999).

In restoring the leaky roof of a palace museum in Laos the builders noticed that the old tiles were not available any more, only one old craftsman still having the skills to make them. They set up an income generating project to revive this old tradition of making roof tiles (Hagemueller et al., 1991). Lack of demand is a serious problem in regard to the preservation of traditional conservation techniques. Orders are scarce even to the officially recognised holders of traditional conservation techniques, and they are often inadequate to maintain their living. In addition traditional materials are currently difficult to obtain (Iwasaki, 1979). Lack of technical information on the preparation and use of local building materials had already been noticed much earlier (Holdsworth, 1959).

The 16th century royal archive building Huang Shi Chen in Beijing, China is in a semibarrel vault structure, built completely of stone and brick, without beams and pillars; even the five huge doors are made of stone. Its surrounding walls are up to six metres thick. This way the temperature inside the structure was bearable in the heat of a Beijing summer and the cool of its winter. In the south of China strong-rooms are surrounded by an enclosed corridor to protect them from direct contact with the external atmosphere (Yao, 1986).

Another striking example of Chinese traditional building is the Tianyi Ge. This private library from 1566 is situated in a botanical garden. In front of the building a water pond leads to the Great Dongning Lake. An ancient Chinese librarian studied and analysed the philosophical relationship between the raw materials of the book: water and fire. Not only can water control fire, it can also help plants grow hence the botanical garden. The owner of the library had his own residence built side by side with the library building, but separated them by two parallel walls. In this way, fire could be prevented from entering into the library building. Moreover, there was a specific and strict rule that fires and candles could never be allowed in the library building (Lin, 1999).

Good natural ventilation is provided in the Chancery Archives of Granada by the simple means of running air pipes from the basement into the repository and thence to the roof. The temperature difference between the roof and the basement ensures a good flow of cool air (Sanchez Belda, 1964). Passive cooling has also long been a feature of Iranian architecture: buildings were clustered together to reduce total surface area; walls were thick and there were few doors and windows while curved roofs provided insulation and encouraged the circulation of air (Bahadori, 1978).

For an overview of traditional dwellings in tropical climates see *Guidoni, 1978*. Further reading, especially on cooling systems in traditional architecture see *Alp, 1987; Cain et al., 1976; Cofaigh Eoin et al., 1996; Denyer, 1978; Fox, 1999; Frick, 1989; Grondzik, 1987; Hassan, 1986; Lewcock, 1978; Moore, 1983; Schreckenbach, 1982; Winterhalter, 1982.* On (traditional) earthen architecture see *Levin, 2001.*

4.6 Location of a Building

Political and financial factors, as well as purely technical requirements often influence the choice of a site for an archive building. Whatever the reasons, the choice of a site is crucial because a mistake cannot be corrected later and can jeopardise the whole future of an archive service (Duchein, 1988). In the past archives were often put up on sites which authorities are prepared to offer. Most of the time, cost and competition for land primarily determines where record offices are built (Thomas, 1988).

According to an older, partly outdated RAMP study several factors have to be considered when a new site is chosen. Amongst other things the site should not be located near areas subject to high levels of air pollution, a major and increasing problem in most of the metropolitan areas in developing countries. Likewise, sites near obvious polluting industries should be avoided, which includes railway stations. Local climatic conditions of possible sites should be studied carefully and preference should be given to ones that are on high ground, have a cool and dry climate and are protected against sun and storms. Locations that are subject to humid, salty or sandy winds, like coastal areas, are unsuitable. At the very least the openings should not face directly into the direction of the prevailing winds. Some environmental protection can also be gained by careful positioning of the structure to take advantage of any natural shade or protection against wind (Daniel et al., 2000; Ezennia, 1989; Ling, 1998; Thomas, 1987).

Paul Gut specifies the site-specific conditions as the presence a pool of cold air, local wind, water, urbanisation, altitude and ground surface. These factors make a real difference and need to be considered in designing the details of the building and in the selection of the construction site (Gut et al., 1993). Rosenberg noticed a rise of 12% in relative humidity inside a museum on the coast of Gabon, while the outside temperature was 7 – 10ºC higher. This was partly due to the location of the building (Rosenberg, 1986). In Fiji the external temperature fluctuated widely on a daily basis, the maximum being between 18ºC and 48ºC. The average fluctuations, monitored during a 54 days period, were between 22ºC and 32ºC (Daniel et al., 2000). The site should also be carefully inspected to ascertain if there are termite mounds or nests in the vicinity (Ling, 1998).

Some sites are more logical than others. If it is intended to build a repository mainly for historical records, it would be advisable to site it in the university quarter or near a library or museum. If, on the other hand, the repository were for semi-current records, it would be better to keep them near the administrative centre. To store archives a long way from town, is not a very good idea. An archive should not be deprived of contact with its potential users: archives are not dead things! (Duchein, 1988).

As time goes by the factors that should apply when selecting the site for an archival repository change. For one, prices for land and housing in the centres of urban areas can rise sky-high. For another, the surroundings of each site need to be considered. Today we distinguish between internal and external factors that influence our choice of the site. Yet, each site and each building are unique (Ling, 1998).

Once a site has been chosen, thought should be given to providing the best orientation of the building. To avoid direct sunlight it is better to orientate the building to the north, in the northern hemisphere, or to the south in the southern hemisphere (Duchein, 1988). Normally north light is recommended as the most suitable natural light for galleries and for conservation studios. The north light is uniform and colours are distinctly visible. East-west orientation, which is favoured by traditional builders in India, is not suitable, unless the walls facing east and west are protected by sun-breakers or wide projections (Agrawal, 1974).

4.7 Underground Building

Building upwards (multi-storeyed), outwards (modular) or down (underground) depends on the amount of land that is available and other restrictions that might be imposed on the land and the overall needs of an organisation (Ling, 1998).

A big advantage of building repositories underground is that the environment is very stable. Yet underground stacks always suffer from humidity and mould (Lee, 1997, Rosenberg, 1986). In a five-year survey of annual temperature differences at the Torazuka old tomb north-east of Tokyo, Kenjo found the temperature difference to be very small throughout the year: while the average highest temperature was 30 ˚C and the lowest temperature was 5 ˚C in the open air, in the tomb the average highest temperature was 17 ˚C and the lowest 15 ˚C. Relative humidity was always around 100% in the tomb (Kenjo, 2000).

Nevertheless, with certain precautions, like special waterproofing, the humidity can be controlled. Before the underground stacks of the National Diet Library in Japan were built, a special waterproof system was developed (Kenjo, 2000). One disadvantage of this type of building however, is that it makes staff feel isolated. The installation of an atrium reduces the ill effects as it allows sunlight to reach right down well into the ground as well as helping to reduce the change of temperature and humidity inside the stacks (Kenjo, 1997). The use of underground storage areas may, in principle, help to reduce energy costs but the high risk of flooding must be taken into account (Schüller, 2000; Tam, 1997).

An interesting western example of a storage facility with a good climate for preservation is the basement of Cologne Cathedral. Here historical documents have been stored under the cathedral for several hundred years and they are in a very good state of preservation (Christoffersen, 1995). Although a subterranean location is a low energy solution for maintaining relatively constant temperatures, there is a corresponding dependence on electricity for all lighting and for humidity control (Bellardo, 1995).

In South Africa, Stellenbosch University has designed one of the largest underground libraries in the world, which is undeniably very successful. Special attention has been given to make the walls and foundations damp-proof. If water enters the area despite these measures it can be easily drained off. Effective roof drainage ensures that all water drained from the outside surfaces of the building is removed via gravitational piping which helps to obviate the problem of condensation. Together with a large mass of earth surrounding the building, these features make the structure react very slowly to any change in the weather (Rowoldt, 1993). In the absence of any storage area in the planning of a small Zambian museum it was decided to alter the plans and incorporate underground storage facilities into the building. This was achieved with the help of Norwegian colleagues who had successfully built underground storage in their own cold climatic zone (Bakken et al., 1987).

The idea of underground storage is closely linked to protection against the risks of war. In addition in areas where land is expensive, as in big cities, it might have economic advantages. Yet, in principle, the cost of an underground structure is much higher than for building on the surface, unless of course an existing underground installation is used. The disadvantage is usually that these are a long way from town and still need essential air-conditioning and ventilation equipment (Duchein, 1988). Underground cells were also prepared in ancient India for the preservation of manuscripts (Swarnakamal, 1975). For further reading see *Labs, 1980.*

4.8 Adaptation of Existing Buildings

To save costs existing buildings are sometimes adapted, or were adapted in the past, to house public records. Many old archive buildings date back to the beginning of the colonial period. The circumstances, under which the documents were kept, were not ideal. In surveys of African archives and libraries the majority of the institutions, especially archival ones, adapted premises to house their collections. Obviously archival and library materials housed in such premises will not receive adequate protection. Adapted buildings are normally old and sometimes dilapidated structures (Khayundi, 1995; Laar, 1985; Mbaye, 1995). Other reasons to adapt or reuse an old building as an archive building include cultural ones, offering a government a chance to put some important architectural heritage to use (Duchein, 1988).

The attitude of archivists to adaptation has changed. In the 1960s opinions varied. By the 1980s, international opinion had turned against recycling, maintaining it would result in buildings which were either expensive, or unsatisfactory, or both. Conversely, and especially in Latin America, countries face the dilemma that archives are seen as the most suitable institutions to occupy old buildings. Unfortunately, there is often not enough money to permit proper conversions that would solve the problems of unsuitable environment, air-pollution and security. Under these circumstances it would perhaps be better to see scarce resources spent on simple and economical new buildings which are in harmony with the natural environment (Thomas, 1988).

This is in agreement with the experiences in Ghana where a regional chief house was adapted to accommodate the National Museum of Ghana. In effect the whole process of redesigning and adapting this building cost far more and took longer than if a museum built specifically for this purpose had been erected. Additionally, it confirmed the preconceived notion that a museum is the place where old and curious objects are kept (Myles, 1976).

It is noticeable that the modern trend is to build new facilities, and not only in the west. To gauge the quality of an archive building first make a thorough inspection of the proposed facility. Apart from functionality one should look for any signs of possible problems. There are many factors to consider when refurbishing an existing building: exterior, walls/floors, walls/doors, roof, drainage, floors, air-conditioning system, duct-work, fire protection, security protection, electrical system, plumbing system, asbestos, light fittings, pests (Ling, 1998). There are several possibilities for adapting recycled archive buildings to tropical climate zones that will help to protect cultural heritage better. One is the radical thermal insulation of buildings and rooms (Schüller, 2000).

Some of the European experiences in adapting archive buildings were discussed at the ICA/CBQ 1989 Meeting in Turin, published as *Janus, 1992(1)* and also at the Expert Meeting, Archive Buildings and the Conservation of Archival Material, held in Vienna, Austria October 30 – November 1, 1985 published in *Mitteilungen des Ősterreichischen Staatsarchivs 1986(39)*, see also *Committee on Archive Building and Equipment ICA/CBQ, 1992; Swartzburg et al., 1991 and Teuling, 1994.*

4.9 Construction

One of the requirements for archive buildings in the tropics is that the building materials should be able to withstand all possible hazards and nuisances, from earthquakes to insect pests. Another, more recent, demand is that construction fabric should have a high insulation value in order to help control the interior climate. Noise pollution, a serious problem in many libraries, is another factor that can be reduced by choosing the right absorbent materials (Singh, 1982). Other requirements are low initial cost, low maintenance, appropriate surrounding buildings, and building materials with good weathering and durability quality. (Ozowa, 1988).

In passive building in South Africa the use of appropriate insulating materials is highly encouraged. It is both economically and practically counter-productive to import products where local alternatives can serve the same thermodynamic purposes (Rowoldt, 1993 and 1994). Local materials are always less costly than the usual reinforced concrete, and may often prove to be superior insulators. There is also less noise from such materials as mud and wattle, or clay (Havard-Williams et al., 1987), but for some reason builders prefer expensive imported materials. In Nigeria most library buildings are built in concrete (Ozowa, 1988). It is unfortunate that during the last decade general interest in the use of appropriate technology seems to have declined.

Selection of building materials is no doubt the responsibility of the architect and not the librarian. But it behoves the librarian to advise the architect because of the discomfort a wrong choice of materials can cause library users, (Ozowa, 1988). Strangely enough Ozowa forgets to mention the impact of a wrong choice on environmental conditions. For all elements of the fabric have a part to play in seeking a total preservation environment – the walls, doors, roof, floors and windows. They should all be designed to come together to form an integrated and sealed unit (Ling, 1998). Or as Daniel puts it: the first task of the building fabric is to reduce the impact of climate loads on the building (Daniel et al., 2000).

In hot climates, load reduction is achieved primarily by shading and ventilation, which serves to produce a more agreeable interior climate. Next, appropriately designed buildings will also reduce the impact of daily extremes of ambient temperature and humidity (Daniel et al., 2000; Toledo et al., 1998a). Some time ago the prevailing idea was that with the introduction of concrete technology and air-conditioning any local climatic conditions may be ignored, or subjugated (Plumbe, 1959b). Today those views are considered superseded (see also section on *Storage – Air-conditioning)*.

Wooden constructions should be made insect-proof or reinforced with metal. However, in buildings near the sea metal constructions should be given additional treatment against corrosion (Duchein, 1980). A very early publication on wood preservation appeared before the second World War in Jamaica (Edwards, 1939); see also *Benoit, 1954a and 1954b; Fortin et al., 1976; Grenou et al., 1951; Keenan et al., 1984; Rauch, 1984; Sierig, 1991a and 1991c; Tack, 1980* (for more see the section on *Integrated Pest Management*).

For bibliographies of building materials for (western) libraries see *Blair, 1993* and for developing countries in general see *Sierig, 1991b.* An older work on building materials and appropriate technology is the number 12 monograph on appropriate industrial technology; more recent ones have been published by SKAT (Anonymous, 1980b; Stulz et al., 1993). See also *Anonymous, 1995b; DBR, 1954; Frick, 1989; Hunderman, 1988; Macleod, 1993; Pama et al., 1978*. The web site of the Canadian Conservation Institute is worth checking, as they intend to pay more attention to research into construction materials in the future.

4.9.1 Walls

A most interesting and comprehensive study of the influence of absorbent materials on relative humidity is the Ph.D.thesis by Tim Padfield. The moderating influence of absorbent materials in small enclosures has been known for a long time. The extension of the concept to moderating relative humidity levels in large, leaky enclosures like houses, has been unaccountably neglected. This failure in building technique has not only neglected the potential for humidity buffering that lies in common materials, but has also generated an array of condensation problems, both within buildings and in the structure of walls and roofs. A strict standard for permissible fluctuation in relative humidity has discouraged any experiments in passive methods of humidity stabilisation, because such methods cannot achieve absolute constancy. In buildings with a very low air exchange rate, such as archives and stores, buffering by absorbent walls is so effective that it evens out the annual cycle of relative humidity, without needing help from mechanical air-conditioning. Padfield tested the performance of different materials and studied their behaviour in situ (Padfield, 1999). He published quite a few interesting studies on passive climate control, one being a scientific analysis of an old Himalayan legend (Padfield, 1987).

The importance of absorbent walls is corroborated by the results in the Vanuatu Cultural Centre, Pacific where the internal climate conditions were monitored for some time. Data analysis indicated that surfaces in the storage room may have higher relative humidity than the air in the room and the air exterior to the building. There was a tendency for this to lead to condensation (Asperen-de Boer, 1968; Daniel et al., 2000). In this context Christofferson developed an interesting factor to define materials capabilities in buffering thermal and humidity variations: The Buffering Capacity Factor (Christofferson, 1995) *(see also section Storage - Passive climate control).*

Today archive buildings are required to have a high degree of thermal inertia so that the interior temperature and relative humidity remain reasonably stable and unaffected by fluctuations in exterior conditions. The fabric of a building and its effect on internal conditions is an area that requires much more research. The potential for passive control of a building's internal conditions by managing the transference of external ambient levels is an exciting one. The current reliance on larger and larger air-conditioning systems is becoming a farce. The ability to control large spaces for twenty-four hours a day is there, but the initial as well as running cost are very high (Rhys-Lewis, 1999).

Hollow bricks made of local materials also provide an insulating effect. In Columbia, for example, an archival facility was built with exterior walls consisting of three layers of hollow brick with air-spaces between, and with steel reinforcement against earthquakes. Light coloured stucco also helps moderate excessive heat, while protecting the building materials beneath from the weather (Bellardo, 1995). Indigenous construction materials, e.g. adobe, can serve as a heat and humidity buffer too (Schüller, 2000).

In Germany the maximum indoor stability of the climate with only very slow changes is achieved by means of the buffer capacity of the brick walls, next to the system of natural air-conditioning (Buchmann, 1998). As the preferred orientation of the building is to the north, the opposite wall facing south has to be well protected from the sun by large projections, balconies or sun-breakers which allow light but exclude direct sunrays and heat. In hot-dry zones west facing walls in particular need to be thick. A 13.5 inch thickness of walls normally provides a ten-hour time lag. Alternatively, cavity walls are considered effective for blocking out heat transmission. East and south walls can be of light construction if protected by overhangs or sun-breakers. In general thick walls will protect the building from solar radiation but external walls need protection from the rains (Agrawal, 1974).

4.9.2 Windows

Opinions are divided on the desirability of windows in storage areas. On the one hand, opening windows can reduce heat and humidity, but on the other hand the existence of windows can increase inside temperatures when the sun is shining. In the industrial world, windows are being used less and less in archive and library storage areas (MacKenzie, 1996). In traditional buildings designers place windows at certain points to create a current of air (see this chapter, section on *Traditional Building).* The idea is that at certain times of the year ventilation is often necessary to improve climatic conditions in storage rooms. Even when an air-conditioning system is installed sliding windows are preferred to fixed windows in case of power failure (Nwamefor, 1975).

The inconvenience of total darkness as in underground buildings must not be underestimated. It is quite possible to avoid such problems and at the same time provide satisfactory protection for severely limited glass surfaces. The following proportions are suitable in tropical countries: 1–5 % of the total surface of the sun facing facades and 1–10% of the total surface not facing the sun. All glass surfaces should be furnished with a protective device (sunshades, screens) in order to avoid the sun's direct penetration into the premises (Karim, 1988). For example in Malaysia the Record Service Center of the National Archives is provided with only small, well insulated glass windows at the top of the wall and these are protected from direct sunlight by sunbreakers (Ismail, 1981).

In monsoon zones windows should be in generous proportions as compared to hot-dry and dry zones. Pierced screens covering the windows or veranda are very useful in this climate, allowing enough ventilation in the rainy season but cutting down direct sun rays as well as solar radiation from the sky and the ground. But behind the pierced screens, it is necessary to provide shutters to the windows, which can be closed when necessary to keep out the sun, cold wind and dust prevalent in this zone (Agrawal, 1974).

Opening a window, lets in dust and sunlight. Simple but effective ways to block the sunlight include blinds, shutters and curtains. Venetian blinds however have the undesirable effect of shutting out the air as well as the natural light, thereby necessitating the use of electric light most of the time (Nwamefor, 1975).

To keep insects out the windows must have screens. Fine wire mesh made from metal or plastic placed over the windows is effective against flying insects. Where there is a danger of hurricanes the windows should be strong and protected by a method of sealing designed to prevent glass breaking, like cyclone shutters, and keeping the water and flying debris out (Duchein, 1988; Ling, 1998). The angles of sun-breakers and window projections need particular care because they should not obstruct the breeze (Agrawal, 1974). Windows must also be designed to withstand heavy rains, especially when driven horizontally by strong winds, or sea-spray (Plumbe, 1987b).

Today, dust contains exhaust gas, which causes new problems. A special window panel was invented in Japan to eliminate particulate matter. The panel has a compound structure: nylon filters are attached to both outer sides to eliminate particulate matter containing exhaust gas. Inside the nylon filters there are micro filters which eliminate bacteria and mould spores. The innermost part consists of honeycomb papers (Kenjo, 1997). This might also be a solution for the accelerated corrosion of metal caused by volcanic gases, at least for internal climatic conditions (Plumbe, 1987b).

Planting trees around the building is one way of controlling the temperature in repositories and keeping the sunlight out as well. The State Archives Department of Vietnam recognised this and put the idea into practice (Tam, 1997). A comprehensive list of shade giving trees is given in *Gut et al., 1993.* The usual advice is to clear an area of vegetation around the building, of at least a few meters, so as not to attract insects that can easily become a problem for archives (Duchein, 1980). Trees can also form a security risk providing easy access to windows as well as the roof (Agrawal, 1974). Big shade giving trees that are not attractive for insects should be sought possibly with the help of ethno-botanists. Trees, green lawns and fountains are a great help in the dry season in monsoon climate zones in cooling the surroundings and reducing solar radiation (Agrawal, 1974).

A simple way to reduce the heat-gain of the building is for the windows to catch the prevailing breezes (Plumbe, 1987b), which should be large according to Agrawal (1974).

4.9.3 Roofs

Pitched or sloping roofs are recommended, specially designed to stand the many and sudden tropical showers as well as the violent winds, from gusty to cyclonic. It is essential that storm water should be thrown off sufficiently far away from the walls so that they are not splashed. A near vertical sun during the hottest hours of the day causes the roof to bear the greatest intensity of heat (Plumbe, 1987b).

The roofing should be tightly fixed and the material should insulate the building from both excessive heat and humidity. Traditional big eaves are recommended as they create plenty of shade around the building and protect the outer walls from getting soaked. Double roofing is an excellent way to create an extra airflow and thus control the inner climate (see the section on *Traditional Building),* but the construction must be storm-proof (Duchein, 1980; Schüller, 2000). The ill effects of a thin pitched roof on a museum environment are well illustrated by a Brazilian case study (Toledo et al., 1998a and 1998b). Metal roofs made from aluminium, zinc, copper or stainless steel have the disadvantage of being very effective heat conductors, as well as possibly suffering from corrosion caused by contact with sulphur dioxide in the atmosphere (Duchein, 1988). Generally all metallic elements exposed to the outside air particularly in maritime zones must be specially treated against corrosion. Flat roofs are not advisable because of the risk of leaking in heavy rains (Karim, 1988)., Flat roofs made of concrete with or without a false ceiling are often subject to cracking due to contraction and expansion (Plumbe, 1987b).

The construction of secondary roofs and facades, with a gap of several feet between the primary and secondary surfaces, to allow for ample airflow around the primary building, is very important. This prevents sunlight from shining on and directly heating the outside surfaces (Schüller, 2000; see also the section on *Traditional Building*). Thermal insulation or the construction of a false ceiling will have a similar positive effect. In hot-dry climates a 4.5 inch thick reinforced concrete slab with 3 to 4 inch lime-concrete or mud-concrete layer provides an eight-hour time-lag for flat roofs. High ceilings do not make any apparent difference to the temperature unless there is a double roof. Compact courtyard planning is effective for this zone; enclosed courtyards retain heat during winter and allow quick radiation of heat and cooling during summer. A pierced screen covering the yard will help to reflect solar radiation from the sky (Agrawal, 1974).

See also the roofing primer by *Stulz, 2000* and *Anonymous 1985a; Koenigsberger et al., 1965; Landaeta et al., 1987.*

4.10 Country and Regional Reports

Africa: Alegbeleye, 1988; Conté, 1996; Hurault, 1997; Khayundi, 1995; Rousseidepina, 1961; Tendeng, 1993; *Australia:* Ehrlich, 1987; Saini, 1970; *Botswana:* Lekaukau et al., 1986; *Brazil:* Segawa, 1992; *Burkina-Faso*: Ouedraogo, 1999; *Burundi:* Faye, 1982a; *China:* Long, 1991; Yao Yu-Cheng, 1986; *Ghana:* Minissi, 1965; *Guinée:* Faye, 1982b; *India:* Kumar, 1981; *Indonesia:* Soemartini, 1986; *Iraq:* Ede, 1980; *Jamaica:* Black, 1980; *Malaysia:* Duchein, 1972; Jones, 1999; Nor, 1986; *Martinique:* Chauleau, 1980; *Morocco:* Abid et al., 1993; *Nigeria:* Alaanyi, 1989; Gwam, 1963; Kwasitu, 1987; Nwafor, 1981; Nwamefor, 1975; Ozowa, 1988; Packman, 1967; *Pacific:* Aynsley, 1980; *Philippines:* Cancio, 1981; *South Africa:* Harris, 1993; *Tahiti:* Saquet, 1991; *Uganda:* Rhys-Lewis, 2000a; *Vietnam:* Imai, 1998.

5.1 Introduction

When the heart of a cultural institution is its collection and the main part of its collection is in storage, then institutions should put taking good care of its heart, its collection in storage as the highest priority. The storage environment can have a dramatic effect on the long-term value of the records and the information they contain (Read, 1994). Even at the design and planning stage of an archive building many initiatives can be taken to influence the storage areas (see section on *Building)*. Thereafter the next step is to look at how a building functions on the inside. The establishment and maintenance of strict environ-mental conditions to preserve records, the key role of a purpose-built repository, is essential. The impact of environmental conditions on records format has been studied by a number of archivists and conservators recently (Ling, 1998). Many criteria can be grouped under the banner of environmental conditions; the most important are temperature, relative humidity, air quality and light. Storage areas can be thermally insulated and should be placed in the centre of the building (Schüller, 2000). Interestingly a study of major Brazilian museums makes it clear that one of the principal factors responsible for the deterioration of objects is the practice of placing them in storage for indefinite periods. Apart from requiring special environmental conditions beyond the means of most Brazilian museums, storage may mean that objects are consigned to oblivion although they could be exhibited without risk (Oliveira et al., 1983). A study of textile conservation, contrasting storage and display issues in Southeast Asian countries with those of the USA, emphasises the underlying impact that climate plays upon preservation strategies. The following aspects play a major role in preservation: the absolute climatic conditions external to the museum, the philosophical and social climate and the interaction of post-production technology, i.e. cleaning and conservation (Ballard, 1992). The findings of INTACH, the Indian Conservation Institute at Lucknow, show that most objects tend to deteriorate not due to lack of air-conditioning or lack of conservation but mainly due to neglect, lack of care and improper storage (Agrawal, 1993). A perfect example that demonstrates, once again, the importance of staff training. Many of the problems manifest in libraries require substantial investment, but they can be ameliorated significantly by a more systematic approach to environmental control and housing, which can be achieved at modest cost (Dean, 2000).

Nevertheless, the first principle that ensures good preservation and storage, whatever the locale or climate, is careful handling of materials (Ezennia et al., 1995).

For an early bibliography on storage see *Plumbe, 1964b,* or another early title by the same author *Plumbe, 1958.* One of the most popular studies on the many aspects of storage is *The Museum Environment* by *Garry Thomson.* Since its first edition in 1978 it has already been reprinted and updated several times (Thomson, 1994). For cheap alternatives in the storage area see *Walker, n.d.* For further general reading on storage see *Anonymous, 1993a; Boustead, 1969; Brommelle, 1968a; Chong, 1990; Lauer, 1979; Obasi, 1980; Pearson, 1997.*

Several topics of major concern when storing the written heritage will be discussed below. If the building is the first line of defence to withstand the external climate conditions, the second line of defence is control of the internal climate of the building. There is an animated discussion on the pros and contras of air-conditioning; an alternative might be passive climate control. The outside air quality is becoming a growing problem. When windows are opened air-pollution is often let in together with fresh air, especially in heavy urbanised areas. Both sunlight and dust can have a devastating effect on the well-being of collections requiring tough measures to keep them as protected as possible. Proper shelving and packaging are essential in preservation. The traditional method of securing manuscripts in insect proof wooden boxes and wrapping documents in plain cotton appears to have worked surprisingly well. Last but not least, good maintenance and housekeeping will do wonders for the building as well as its holdings.

5.2 Internal Climate Control

Eighty years ago Chapman had already published two articles in which he demonstrated the devastating effect of the tropical climate in Calcutta on the collections of the Imperial Library of India (Chapman, 1919 and 1920). Since then our understanding of the process of degradation of paper has increased appreciably. Nevertheless, from a practical standpoint, most libraries in tropical countries still face the same challenge. Undoubtedly, the most cost-effective preservation measures can be developed from exploitation of the storage environment. The environment is an ever-present factor, which inexorably influences the rate of deterioration of all collections (Shahanietal.,1995). High temperature has two effects on paper. Firstly, it speeds up the rate of chemical activity and thus the rate at which archival material decays; for every increase in temperature of 10 °C, the rate of chemical activity generally doubles. Secondly the rate of biological activity also increases; damage caused by insects and moulds is much greater at higher temperatures (see also section on *Integrated Pest Management*). The main danger of high relative humidity is that it will lead to an increase in such biological activity; mould will only grow above 65–70% relative humidity, while most insects flourish at higher humidity. Dyes will fade at a faster rate at higher relative humidity (Thomas, 1987).

Sudden or repeated fluctuations of temperature and relative humidity, the two main factors responsible for the climate of a place, may spell disaster for susceptible types of objects (Agrawal et al., 1974). Changes in temperature will cause materials to change dimension, sometimes quite markedly. This poses a problem for complex records made from two or more substances, each of which has a different thermal coefficient of expansion, thus imposing stresses on the structure of the record. Repeated cycling of temperature can cause permanent damage. Changes in relative humidity will cause materials to change dimension, as is the case with fluctuating temperature. This can have marked effects on complex items. Books exposed to damp conditions will have swollen and wavy edges but will develop tight edges and baggy centres if they lose too much moisture. Repeated cycling may lead to permanent damage (Thomas, 1987).

To some extent the relative humidity can be controlled by using suitable cotton carpets of reasonable thickness on the floor of the gallery, as these carpets absorb sufficient moisture from the air (Swarnakamal, 1975). At a 1993 seminar on *Preventive Conservation in Latin America* most participants agreed that protection from damp environmental conditions had to be given priority. It was pointed out that this preventive effort would do more for the long-term preservation of collections than any individual or mass treatment (Raphael, 1993). A popular way to reduce the high moisture levels in the air is the use of portable dehumidifiers or moisture absorbing crystals. Small low wattage (50–100 watt) heaters can also be used, though only in very small, confined areas. They too help reduce the moisture from the air. They are not expensive nor do they consume large amounts of electricity (Ling, 1998).

In 1997 the Getty Conservation Institute started a project that focuses on developing economical and sustainable strategies to improve physical environments of collections in historic buildings in hot and humid regions. The project aims at researching alternatives to conventional air-conditioning systems by studying the control of relative humidity through ventilation and heating, while allowing larger variations of temperature. The institute developed a set of guidelines for evaluating the environment of museum collections and their buildings (see *GCI website*).

Thus the control over temperature and relative humidity is generally accepted as a method of reducing degradation of collections.

The maintenance of storage conditions to established parameters is the most vividly discussed issue in storage conditions; proper temperature and relative humidity are the subject of continued debate. Yet most researchers tend to agree that the present norms for all archival materials are too tight and that stability of both temperature and relative humidity is at least of the same importance (Banks, 1999; Buchmann, 1998; Christoffer-son, 1995; Porck et al., 2000; Rhys-Lewis, 1999). Norms for both temperature and relative humidity depend largely on local climatic conditions (Thomas, 1987). Strangely enough these are not always taken as a standard. Any tropical institution that tries to achieve the environmental control specified in standards for temperate zones is likely to give up and not even exercise the control measures available to them (Ballard, 1992; Clements et al., 1989). It is of the utmost importance that keepers of important cultural collections are aware of the diverse standards and differing prerequisites. What is a minimum in one country can be a maximum in others, and may be regarded as an optimum in another (Fröjd et al., 1997). One should not lose sight of the fact that any standard is nothing more than a set of compromises among the participants (Shahani et al., 1995).

Temperature and relative humidity data have been the most frequently reported over the past 20 years, but the results are often of little practical use, due to the limitations and unreliability of the monitoring. Reliable monitoring data is essential before deciding on the performance of a building; it will illustrate whether the building helps or works against the preservation of collections. A guide to external conditions can be provided by the data from the local meteorological office, if not too far away from the location. Several guidelines for designing a monitoring system should be followed in order to obtain reliable parameters (Daniel et al., 2000) and some monitoring reports have been published over a period of 10 years (see also Rosenberg, 1986).

In a PhD-study on museum environment in Brazil two naturally ventilated historic buildings from the 18th and the 19th centuries were compared with a modern air-conditioned one. In this study the 19th century building had the most stable climate probably caused by its veranda coupled with its opening regime. On the other hand, the 18th century building was the most problematic, probably due to its thermal inertia, coupled with its opening regime (Toledo et al., 1998b). On a microclimate level both Kamba and Stolow studied the use of natural materials as buffers for relative humidity (Kamba, 1987; Stolow, 1966).

The relationship between relative humidity and temperature is excellently shown in the Preservation Calculator from the Image Permanence Institute (IPI). It shows the natural ageing rate of organic materials at a certain temperature and relative humidity, how long it takes, for example, for paper to become brittle, and how long it takes for mould to grow under specified conditions. It works with the so-called Preservation Index (PI), a concept introduced by the Image Permanence Institute in 1995 to express the 'preservation quality' of a storage environment for organic materials. The Preservation Index has units of years that reflect the possible problematic behaviour of the preserved objects. The higher the Preservation Index, the better conditions are for preservation of organic materials. Preservation Index values in years were designed so that the Preservation Index of 20°C and 45% relative humidity (recommended conditions) was 50 years. However, the recommended conditions were set for temperate climates and not for tropical ones. Nevertheless this tool, which can be downloaded freely from the IPI website, gives a good insight into the relationship between temperature and relative humidity.

See also *Agrawal, 1977; Brommelle, 1968b; Drummond, 1999; Erhardt et al., 1994; Freemantle, 1988; Grove, 1961; Gut, 1993; Kamba et al., 1988; Lull et al., 1995; Padfield et al., 1990; Scott, 1994.*

5.2.1 Air-conditioning

Air-conditioning is frequently not an option for archives in developing countries. That is why passive climate control offers a more attractive way to control the physical environment. Air-conditioning might be an answer to control excessive heat and relative humidity, but it is not one that many can afford. It is not just the cost of installation, there is the need to maintain the system and the running cost, i.e. the electricity bill (Agrawal et al., 1974; Akussah, 1989; Aranyanak, 1988; Coates, 1995; Karim, 1988; MacKenzie, 1996; Toledo et al., 1998b). Even in the 1960s caution was being recommended (Rousset de Pina, 1961). One report from Sierra Leone shows that of the air-conditioning systems acquired in the late 1960s and early 1970s, all except one had become defective and neither repair nor replacement proved feasible (Wagner, 1985). In Nigeria none of the original centralised air-conditioning systems proved functional. They were replaced by unit or split systems (Egbor, 1985). There is much debate about centralised whole building systems or split systems, although the outcome of the experiment at Jos University in Nigeria, where 16 different units were installed, was very positive. Using decentralised systems reduces the chance that the whole building will be without air-conditioning. Most of the authors want to avoid central air-conditioning

(Egbor, 1985; Nwafor, 1980; Singh, 1982). This is corroborated by the outcome of the African survey from 1998 in which only 15% of the purpose-built buildings had air-conditioning (Coates, 2001).

Because of poorly operating air-conditioning systems the conservator often has to resort to free-standing dehumidifiers or silica gel in order to exercise some control over the humidity (Aranyanak, 1988); (see also Boustead, 1968).

Often archivists hold the mistaken belief that if a comprehensive air-conditioning system is installed all will be well. It is now clear that this view is entirely erroneous. In essence, the fabric of a building must create a sealed environment that is then complemented by an air-conditioning system. The system itself cannot make up for deficiencies in design and construction (Ling, 1998; Rosenberg, 1986). Unless highly reliable (and highly expensive) systems are used, the presence of air-conditioning can often cause more damage than if it had not been installed. There have been reported cases where air-conditioning has been installed in previously unconditioned buildings with disastrous results, particularly problems of relative humidity (Daniel et al., 2000). Petherbridge noticed that in two hot, humid countries money had been invested in air-conditioning in archive holdings. In both cases, however, only the temperature was lowered, effectively raising the humidity even further. Consequently the collections deteriorated even more quickly (Giese, 1995).

If an air-conditioning system is installed it is essential that the system runs continuously, even in the silent hours. There is no point in switching it off at night or at weekends. While you may save on energy, the degradation of the records will be hastened. However, during a cyclone warning the system should be turned off. The reason for this is that the building may be damaged by wind, rain or lightning. If the air-conditioning system is operating, there is the possibility that the damage could be made worse (Ling, 1998).

In 1997 the thermal and hygrosmetric behaviour of both an air-conditioned and a non-air-conditioned storage area of the Fiji Museum at Suva was monitored for 54 days. The museum is located on an island in the Pacific. The building is located close to the coast and is very typical of most modern buildings in tropical climates, being constructed mainly of concrete. The results indicate that the daily fluctuations of relative humidity and temperature in the air-conditioned space, as compared to the non-air-conditioned room, were significant (Daniel et al., 2000). It is therefore of great importance to consider whether any other system than air-conditioning would have a sufficient effect on the museum climate, whether anything can be done, through orientation and designing of the building, to control the indoor climate, if not fully, at least to a certain effect (Agrawal et al., 1974) (see also section on *Building*). For further readings see *Adamson et al., 1993a* and *1993b; Anonymous, 1961; Baxi, 1974b; Cottell et al., 1983.*

5.2.2 Simple Mechanical Provision

Much can be done besides the air-conditioning systems so many conservators crave for. Simple measures to reduce the solar gain in temperature include shutters, blinds and curtains. Curtains should not be pleated but framed between horizontal supports to prevent dust collection. They should also preferably be white to reflect the sunlight (Hagmueller et al., 1991).

Simple electric fans can also be used to keep air circulating and offset some of the effects of high temperature and humidity (MacKenzie, 1996). According to Ling, ceiling fans will aid the process of adequate ventilation but will not actually lower the temperatures or relative humidity levels, they merely keep the air moving (Ling, 1998). The location of the fans or other type of air circulators in a museum environment should not be disturbing to staff or visitors (Agrawal et al., 1974). In the Vanuatu Cultural Centre high air movement and air exchange is promoted as a strategy to reduce high humidity and condensation problems in the storage area (Daniel et al., 2000). Electrical ventilators are much less appropriate than roof fans (Hagmueller et al., 1991).

For adequate ventilation one should rely on natural through-draughts. The provision of small windows at floor level will improve the circulation of air. Of course unnecessary internal doors, walls or screens should not block the free movement of air. Compare for passive climate control the section on *Building – Sustainable Building – Passive Climate Control.*

5.2.3 Air Pollution

The cultural heritage, man's valuable possession, is in great danger of extinction today because of adverse environmental conditions and air pollution. Air knows neither limits nor state boundaries. It is a resource which is shared by the entire nation or, more realistically, the entire world. Air pollution is a socio-technological disease born out of the Industrial Revolution. It is an undesirable change in the physical, chemical and biological characteristics of the atmosphere, caused mainly by compounds which are present 'in the wrong place, at the wrong time and in the wrong concentration'. The pollutants have a disastrous effect on life and materials. Deterioration of archival and library materials, which is greatly influenced by the prevailing environmental conditions, could be retarded by maintenance of ambient environmental conditions in the storage area. Simple measures like the use of acid removers, dust removers, sun blinders, dehumidifiers etc. might help to mitigate the effects (Joshi, 1995). Most libraries are located in urban, industrialised centres, with the result that the atmospheric environment is full of pollutants, placing library materials at risk (Ezennia et al., 1995). In Nigeria oil producing regions cause thermal pollution either from the high temperature present in discharges or from the flaring of gas. It also contaminates the rain water and contributes to the acid deterioration of books and paper (Aziagba, 1991).

Dust-laden winds often contain impure air with damaging quantities of all kinds of gases. These will cause oxidation of some library materials. As well as the indirect effects of heavy winds, like bush fires and excessive ultraviolet radiation, these conditions produce their own share of deterioration (Ezennia, 1989). Even when conditions outside become so bad as to preclude bringing large quantities of air inside, good air circulation within the building is important, using fans as needed. It is important to locate intake and exhaust fans along the axis of stack aisles with exhaust fans placed high in the walls. Air intakes should be positioned to pull air into the building that is as pollution free as possible. Intakes should not pull in vehicle exhaust, or smoke or exhaust from nearby structures or the archives building itself. The idea is to exhaust stale air, while pulling fresh air into and through the stack areas of the building. In many countries a finely woven cloth material can be fastened over the windows. This permits the air to enter, but eliminates much of the dust. In a Costa Rica museum it was noticed that the interior side of the curtain appeared clean, while the exterior side was extremely dirty, indicating that the cloth was acting as a natural filter (Bellardo, 1995). An interesting feature of the Japanese tatami mat, a thick floor covering made of a rice straw core with a reed surface, was discovered by researchers from Tokyo University. They found that the tatami helped to remove nitrogen dioxide from the atmosphere. Although the mechanism in the purification process is still unknown, the researchers found that the nitrogen dioxide content of a tatami room is less than half the level out of doors. A unique way of fighting the heavy air-pollution in Tokyo (Wills, 1987).

State-of-the-art repositories use chemical filtration to remove pollutants from the air. Even without an expensive filtration system, there are a number of ways to limit the effects of pollutants. One important way is to house records within folders and boxes that meet the standard for permanence. The alkaline reserve in these materials will serve as a buffer between the contents and a potentially harsh environment. Boxes and folders meeting the international standards will create a stable micro-environment for permanent records (see section on *Preservation and Conservation)*.

It is evident that the choice of the site of the archives building is essential in avoiding air-pollution (see also section on *Building - Location of A Building*). Many urban areas in developing countries have to fight a huge air-pollution problem mainly caused by the exhaust fumes from all kinds of motorised vehicles and indirectly by the lack of a public transportation system. The western countries are not helping either considering the controversies on the Kyoto Treaty about the global fight against pollution. In addition, critics argue that the west is exporting their own considerable pollution problem to developing countries.

The Getty Conservation Institute continues its research on pollutants in hot and humid environments under a new project *Performance of Pollutant Absorbents*. For an impressive European study on the effects of air pollutants on paper see *Havermans et al., 1994*. The RAMP study by Pascoe on the impact of environmental pollution is outdated, but more recently guidelines were published by the Museum Association in the UK (Blades et al., 2000; Pascoe, 1988). The website from the Danish specialist Morten Ryhl-Svendsen gives an updated bibliography on pollutants. This site can also be consulted for the latest news on the 4th meeting of the Indoor Air Pollution working group (IAP) in Copenhagen, November 8–9 2001. See also *Pearson, 1988.*

5.3 Sunlight

Light, whether natural or artificial, can weaken some materials, causing them to fade or darken. Damage from light is irreversible, and the effects of exposure accumulate over time. A record exposed to a dim light for a long time will ultimately show the same effects as a record exposed to a bright light for a short time. Thus it is imperative to reduce exposure as far as possible (Read, 1994). In tropical countries the main light problem for libraries is solar radiation entering the facility. Roofs, walls and windows all need to be designed to direct or obstruct the sun's rays (Plumbe, 1987b). Indirect light can be used to provide light even in stack areas, if used with care. First, aisles should be orientated so that light passes through the aisles, and not directly onto the records. Second, windows should be deeply recessed, and roofs built with a large overhang so that sunlight only enters indirectly. It is also possible to utilise skylights that transmit sunlight reflected off walls covered with paint containing ultraviolet-absorbing pigments, such as white titanium dioxide (Bellardo, 1995); (see also section on *Building*).

Sunlight contains a high proportion of harmful blue, violet and ultra-violet rays. Frequently humid atmospheres increase the danger of this radiation by causing greater refraction of the rays. Under these circumstances it is particularly necessary to protect records from sunlight (Duchein, 1988). It is not only the direct sunlight that eventually reaches the surface of the earth that troubles the conservator. He has also to take into account the indirect sunlight that can reflect from different sources (Plumbe, 1987b).

For prestigious reasons the French built their new Bibliothèque Nationale de France in four glass towers. One effect of the transparency of the high-rise was the free access of the sunlight to the interior of the building. To prevent heat gain movable wooden panels were installed on the inside of the windows, but unexpectedly this created a microclimate that gave rise to such high temperatures that the windowpanes cracked. This shows that not all measures taken to avert the sunlight are effective.

The negative influence of the sun on a collection in a historic wooden building in Japan was clearly proven in a study by Toshiko Kenjo. It appeared that the collection located at the innermost of the room on the east side, where the sun light struck the least, was most effectively protected from the sun shining (Kenjo, 1987).

It is not very logical in hot climates to build at great height. It certainly allows for a relatively small roof area, but it greatly increases the wall areas on which intense solar radiation falls. Roofing and walls that either in material or colour reflect the heat from the surface will diminish solar heat. Eventually solar control can be accomplished by many means: overhanging roofs, curtains on the walls, projecting fins, panels, pierced screens, louvers, shades above windows. Screens should not be placed too near windows, as they will radiate the heat after sundown. In a museum building, natural lighting, with all its faults, cannot be ignored. It can be reflected, screened and diffused so that it is without glare and produces less ultra-violet rays. Light entering through high windows reflected by the ceiling is adequate for galleries (Agrawal et al, 1974).

There are also cultural differences involved. In the West people like bright lights, but in Southeast Asia people feel more comfortable when the light is low, because of the association of heat and light in the tropics (Ballard, 1992). Perhaps archives, library and museum staff tend to underestimate the self-regulating mechanism of the local population. In Venezuela there is a saying: *only donkeys and tourists walk in the sun*. For further reading see *Doe, 1965*.

5.4 Dust

Dust is another factor, besides temperature and relative humidity, that creates a great risk in tropical areas. It has an abrasive and deleterious effect upon paper and it encourages the growth of mildew (Plumbe, 1987c). It is omnipresent in practically all countries in the hot-arid zone. It can be encountered in the form of violent dust storms variously called *haboobs*, *simoons*, or *ajaj*. Ghana and northern Nigeria are greatly inconvenienced by the dust-haze called *harmattan*. This dust laden dry wind blows from the Sahara Desert between November and mid-March (see also section on *Disaster Preparedness – Forest Fires*). In most cases this wind carries clouds of red dust, which form a dense haze. Harmattan mornings are cold and misty but the mist disappears with the increasing sun of the morning. Apart from affecting people and other living organisms, the wind also affects library resources. Books become brittle and the glues and paste used in bindings disintegrate. In addition the strong wind carries many insects increasing the potential for book damage. The harmattan air also causes oxidation of some library materials (Ezennia, 1989; Plumbe, 1987b).

Other areas where buildings severely suffer from dust storms include the southern states of the USA. The building of the Historical Society of Montana is located facing the sandy barren plains on one side. The very small particles of sand cause much damage to the holdings in the repository. The sand particles are so fine that they find their way through the cracks between the brick wall and the window frame. To diminish the problem the keepers put up curtains in the windows. When the curtains were examined under the microscope the severity of cuts in the fabric demonstrated how harmful regular dust-laden winds can be (personal communication from the staff of the Historical Society of Montana).

The fact that air circulation is one of the principles of personal well-being is most frustrating for conservators. As a result windows are normally left open, fans are kept moving and dust flies freely about and covers just about everything (Schüller, 2000). To keep out the haze of fine dust the windows must be sealed well and grooves must be without cracks (Plumbe, 1987b). In addition shrubs and trees can reduce the strength of dust-laden winds (Gwam, 1963; Kumar, 1981).

Once the dust storms have passed cleaning up should be done as carefully and rapidly as possible (Plumbe, 1987c). Cleaning should be carried out regularly using a powerful vacuum cleaner so as not to stir up the dust during removal (Davison, 1981). Sweeping the floor with brooms, which is the regular cleaning method in most developing countries, is not recommended. It only redistributes the dust particles.

Next to dust coming from outside the building, dust is also created within the building. The main source comes from bare concrete floors, which are crumbling. Consequently, it is absolutely essential to provide a protective covering for the floors. Other sources of dust are the documents themselves. On arrival at the archive they should all be dusted in a separate room (Duchein, 1988; Gwam, 1963).

5.5 Shelving

As long ago as 2000 BC Mesopotamian archivists stacked clay tablets on shelves off the floor and away from the walls to protect the vulnerable clay from damp (Banks, 1999).

In most cases shelving has been provided as a result of colonial administrations and is often of wood construction, although varieties of metal shelving have been introduced. Generally there is much work to be done on standardisation and significant improvements could be made by strengthening and securing shelving – especially cross-bracing and wall fixings. Raising shelves above ground level must be a priority, as this will greatly improve the life expectancy of stored materials. These best practices are vital and easy to achieve (Rhys-Lewis, 1999).

Adjustable steel shelving is highly recommended, because of its strength and resistance both to fire and insect attack. It should have a baked enamel finish to resist abrasion and corrosion. Since archive material does not come in standard sizes, flexibility in shelving is important. Wooden shelving is acceptable providing it is sealed with an acrylic paint or varnish (for painting problems see *Adefarati, 1980*). Then again wooden shelves have the drawback of being combustible and they are also vulnerable to the attack of termites. Yet, in most tropical countries many local timbers are suitable for furniture and shelving, many are resistant to fungal infestation and certain timbers are termite-proof (see also section on *Integrated Pest Management*). A disadvantage of wooden shelves and furniture, particularly inadequate seasoned wood, is that it will swell or contract according to the humidity. Next the (animal) glue may weaken and imperfectly constructed wooden items may tend to fall to pieces (Plumbe, 1961c). Cement is, in the first instance, not an alternative as it is not flexible and very often creates dust (Pérotin, 1966). Yet, there are exceptions. Local archives in Africa suffer heavily from one particular termite (Pseudocanthotermes) which does not have an epigeal termitary and is spread out everywhere. Only cement stops them and in combination with metal supports, bars or grills this provides the best security against termite infestation (Hurault, 1997).

Generally, sharp edges and rough surfaces should be avoided. The shelving chosen should allow the greatest air-circulation; solid shelves and back panels should be avoided. Compact shelving is inadvisable because it interferes with the circulation of air (Duchein, 1988). Avoid shelves running against an outside wall, as they may conduct damp and impede the free flow of air. Setting the shelves at right angles to the walls creates a better airflow. This is also necessary to avoid the development of fungus in places which may not be well aired. For the same reason full sheet iron must be avoided and instead cross pieces or ladders, which permit air to circulate amongst the shelves, must be adopted (Karim, 1988; MacKenzie, 1996).

In case of insufficient shelving when records must be stored on the floor, some type of blocks or pallets should be used so that records are not directly in contact with the floor. If the cost of new shelving is beyond reach, it is sometimes possible to purchase second hand shelving. This must be cleaned thoroughly prior to use and it may be necessary to have it resprayed in case of bad damage (Ling, 1998). It is obvious that shelving should be sufficiently sturdy to withstand earthquakes, and in this case back panels should be considered (see section on *Disaster*

Preparedness – Natural Disasters – Earthquakes). The NAA (National Archives of Australia) recently developed guidelines for mobile shelving (NAA, 1997).

For some experiences, mainly in the West, with different archival shelving systems see *Atlanti (International Institute for Archival Science, Maribor), 1993.*

5.6 Handling

It is now recognised that poor handling of books and records by staff and users in archives is one of the greatest threats to their well-being. Every time a book or document is taken out of storage, manipulated by hand, exposed to light or to a different environment, some damage occurs to it. On the other hand, archive collections are preserved in order to be used. A proper policy on handling, by both staff and users, is necessary (MacKenzie, 1996).

In western librarianship rare and valuable books are treated with special care. These rare books and manuscripts are often housed in Special Collections and different standards for ethical conduct are even developed for such books (*American Library Association, 1993),* (see also *Datta, 1969*). This is not so in most non-western countries. In many libraries every book is rare and valuable. It has been purchased with financial resources that are scarce and diminishing in value and amount. Usually it has been imported from abroad, taking a number of months to arrive. If it wears out, there are no funds to replace it. There are no funds to buy materials to repair it. There is little to repair it with. There is little expertise to repair it. Each book is being used more, as the rate of acquisition slows down, because of the lack of money. Users have not grown up with books and their living conditions do not make it easy for them to care for the books they borrow. The librarian's chief concern is to keep every book in circulation for as long as possible and at no extra cost to the library. Conservation spending must not be put before money spent on staff. In such a situation, the care and attention paid to the handling of books brings dividends in slowing down the inevitable damage caused by wear and tear. It was this experience at the University of Juba that gave Diana Rosenberg the conviction that everyday care of library books should be given special emphasis in any preservation measure taken by an African library (Rosenberg, 1995).

This realistic account certainly brings conservation in developing countries into perspective and justly stresses the importance of proper handling of library and archival materials. Every day care, Diana Rosenberg continues, is one aspect of preservation and encompasses all measures that are taken to improve the physical handling that takes place each and every day as books circulate amongst the library users. It involves both actors (library staff and users) and activities (cleaning, shelving, use, photocopying and minor repairs). Diana Rosenberg ends her interesting lecture with some guidelines and checklists that might provide a base for any library deciding to review its every day book care measures. Proper handling techniques do not demand a high-tech approach, nor do they pose a threat to people or the environment. Every day care does require discipline on a continuing basis (Bellardo, 1995 ; Dartnall, 1988).

Next to handling, proper display is highly important for safeguarding artefacts. Again, the fluctuations in temperature and relative humidity are crucial. High altitude Quito, Ecuador has a near perfect climate; dry and cool, with a low atmospheric pressure. Such conditions are wonderful for preserving books and manuscripts. Here, apart from some problems with insects, masses of documents collected by religious orders and the Spanish colonial administration remained in good condition for centuries. In recent times, however, inappropriate display in modern gallery and library buildings elsewhere has caused rapid disintegration of some of these collections (Giese, 1995).

For general information on handling see *Agebunde, 1984; Forde, 1991; Tlalanyane, 1989.*

5.7 Packaging

5.7.1 Boxes

In western archives it is now generally accepted that all record materials other than bound volumes should be placed in some form of secondary enclosure. This protects the items from dust and dirt, allows them to be transported safely and is the first line of defence in the event of fire and flood. It can also help even out fluctuations in temperature and humidity, producing in effect a microclimate around the item (MacKenzie, 1996), (see also Coremans, 1968). The cheapest and most effective way of providing a reasonable measure of protection against all kind of hazards for all records (including bound volumes) is to put them in boxes (Thomas, 1987).

In antiquity people usually stored their documents and books in some kind of casing. Egyptians, Greeks and Romans stored their scrolls in cylindrical boxes of wood and ivory. In India, as elsewhere in the East, fragile palm-leaf manuscripts were protected first by fastening them between strips of wood or carved ivory and then by covering them with a cloth piece, called *bastas* (Kathpalia, 1973; Plumbe, 1959b). The same practice was noticed in Laos and other countries in continental Southeast Asia (Giese, 1995; Hundius, 2000). In some countries such boxes traditionally have legs in order to further air-circulation. Sometimes double boxes are used: a box in a box. The woods of such boxes are often insect-repellent, like cypress-, cedar-, or paulownia-wood, and vary according to country (Jourdain, 1990; Kathpalia, 1973; Kenjo, 1997; Plumbe, 1959b), (see also section on *Integrated Pest Management*). Important Chinese records and manuscripts were kept in wooden chests made from rosewood or ebony covered with brass plates and placed on a platform in the room, keeping them relatively safe from fire (Banerjee, 1997; Li, 1995; Yao Yu-Cheng, 1986).

The National Palace in Korea traditionally used wooden closets to store their records and manuscripts; today they have replaced them with aluminium ones built off the ground (Su, 1979). The Japanese storage container, a paulownia-wood box, is specifically constructed to respond to changes in humidity. Paulownia is a soft, hygroscopic material, and this characteristic, coupled with the highly developed skills of the box-maker, ensure that when the humidity does climb, the lid and base of the box close very tightly and form a barrier between the environment and the interior of the box. Desiccating agents, too, are occasionally found in old boxes. The most common are small bundles of straw or similar material placed at the bottom of the box (Wills, 1987). In Tunisia the wooden boxes were treated with olive oil to withstand the salty humidity of the coastal climate and in the Sahara the fresh wood was rubbed with palm oil to prevent it from drying out and cracking (Jourdain, 1990). Measuring the changes in temperature and relative humidity inside the preservation boxes Toshiko Kenjo concludes that they are very low. If double preservation boxes were used, changes would be even less. The wood material, however, should have been dried naturally and sufficiently until no resin is emitted (Kenjo, 2000).

The provision of cardboard boxes has improved the initial situation where archival documents were kept in bundles or box files. In many cases the metal clasps and attachments have become rusty. Higher quality cardboard boxes can be added as resources allow (Rhys-Lewis, 1999). Archive boxes with pull cords are preferred over those with holes through the box wall, because they protect the records more fully. Multiple layers of paper separated by air pockets are especially helpful. For example, records within a wrapper or folder that is placed within a closed box can be placed within a larger closed box (Bellardo, 1995). For the Mass Preservation Project at the National Archives in Asunción, Paraguay Alvaro Gonzàlez designed a box and protective enclosures for the valuable and seriously damaged collection of manuscripts from the 16th–19th centuries. The box style, which was given the name ‘Paraguay’, proved to be very resistant to the subtropical climate (Esteva, 1993).

Instead of altering a large space, such as a large stack space, a measure of control can be obtained by creating micro-environments. Such protective enclosures not only add an insulating layer to reduce the effects of varying levels of temperature and humidity, but can provide also other opportunities for control (Dean, 2000).

In the Fiji Museum in Suva monitored climate conditions showed that a wooden artefact wrapped in a simple plastic bag minimised the daily fluctuations of temperature and relative humidity (Daniel et al., 2000).

5.7.2 Wrapping

Preferably records should not be left uncovered. Often old documents are covered with either paper or cloth wrappings before being put away in boxes. In ancient times the palm-leaf manuscripts were kept in wrappings (Kathpalia, 1973). In order to repel insect attack certain leaves were kept next to the manuscripts. Red is generally the repelling colour for the insects that attack books and manuscripts. Silk is also remarkably immune to book worms. So red coloured silk should be used for wrapping palm-leaf manuscripts (Berdigalieva, 1995; Swarnakamal, 1975). In a conservation programme in Laos palm-leaf manuscripts were wrapped in cotton cloth and kept in appropriate, recently manufactured glass-fronted bookcases (Noerlund et al., 1991). If no boxes are available the records can be wrapped in plain paper, not newspaper or coloured paper as the printing ink might rub off or the colours might bleed (Ling, 1998). Wrappers used to protect bundles of records are often found covered with dust and even soot, while the records inside are clean. The worst thing to do in such situations is to remove the wrappers and leave the clean records exposed to dust and pollution. Good paper that meets international standards for permanence may not be available locally or may not be affordable (see also *Preservation and conservation – Appropriate technology*). If that is the case, custodians should first try to obtain alkaline paper. Cigarette paper is available in many countries and is generally alkaline though not very strong (Bellardo, 1995).

5.8 Good Housekeeping

It is important to ensure a high level of good housekeeping. The building in which library materials are stored should be kept clean and in good condition (Thomas, 1987). But adequate maintenance procedures constitute a big problem and have plagued tropical countries for a long time (Egbor, 1985). Internal housekeeping measures should always be of a high standard. Obviously, food and drink should never be taken into storage areas. Proper receptacles should be provided in canteen and restaurant amenities, which should be cleaned regularly. Foodstuffs should never be left overnight, uncovered or in unsealed containers (Ling, 1998; Rhys-Lewis, 1999). When lending books personal hygiene and housekeeping at the users’ home, are also important factors to keep in mind (Ezennia et al., 1995). Good housekeeping is well illustrated by the Dr. Albert Schweizer Museum in Gabon. Compared to the other buildings on the premises, which were cleaned less often, Schweizer’s quarters were surprisingly well preserved (Rosenberg, 1986).

Building maintenance can also be considered as part of good housekeeping. The archive will be there for a long time protecting records and providing a working environment for staff and visitors. In recent years there has been an emerging trend in western countries to outsource maintenance activities, outdoors as well as indoors. Many standards have been developed to maintain buildings, equipment and services. It is often thought that maintenance begins following the completion and handover of the facility, but in truth it starts well before that. It begins as part of the building’s overall design, which should include the requirement that it is constructed from low maintenance materials (Ling, 1998). The suitability of the sustainable materials and constructions for maintenance should be considered especially carefully.

In tropical settings, the power supply can sometimes be erratic and surges or spikes are not uncommon. Similarly, violent electrical storms can wreak havoc to equipment such as computers. To compensate for the effects of a complete power failure, including a shutdown to the air-conditioning system or PC-network, a reserve power supply may need to be considered in the form of an auxiliary generator. Protection against power surges can be accommodated by means of an UPS e.g. an Uninterrupted Power Supply unit (Ling, 1998). It is still true, however that the major threats to records come from human beings. Records can be damaged by mishandling, carelessness, or by deliberate criminal activities, including theft and vandalism (Thomas, 1987); (see also section on *Disaster Preparedness – Manmade Disasters*). For further reading see *Christensen, 1989.*

Chapter 6 : Disaster Preparedness

6.1 Introduction

Disaster: it strikes anytime, anywhere. It takes many forms – a hurricane, an earthquake, a tornado, a flood, a fire or a hazardous spill, an act of nature or an act of terrorism. It builds up over days or weeks, or hits suddenly, without warning. Every year, millions of people face disaster, and its terrifying consequences (Federal Emergency Management Agency FEMA website).

It is believed that the number of natural disasters is increasing worldwide because of climatic changes. Still, disasters fascinate people. They induce feelings of amazement and fear, and provide examples of courage, folly, and tragedy – in a sense, all the aspects of a great drama. Disasters are media events and frequently inspire Hollywood as most recently evidenced by the movies *Twister*, *Dante's Peak*, and *Volcano* (Musser, 1997). But until you have experienced a disaster, it is hard to imagine the sense of shock and helplessness they generate. It almost goes without saying that we need to minimise the damage caused by various types of disasters. Any archive should be prepared for the worst, be it located in the west, east, north or south. A disaster, or emergency, encompasses everything from a forgotten open window during a rainstorm to a major earthquake, and everything in between that puts the holdings in jeopardy (Trinkaus-Randall, 1995).

Disasters strike worldwide. This becomes very clear when reading the tragic UNESCO report on the lost memory of the world (Hoeven et al., 1996). In the course of time every country is confronted with damage to their cultural heritage as a result of either wilful or accidental destruction. Local authorities and communities, especially those in tight economic circumstances, do not understand the benefits to be gained of reducing losses today for an unknown tomorrow (Gavidia, 2001). Not surprisingly developing countries are hit harder by disasters than countries with economic wealth. For the more wealthy countries it is of course much easier to invest in the prevention of potential risks.

Disasters need to be managed in order to control them or at least to mitigate the effects. According to the Caribbean Disaster Emergency Response Agency (CDERA) the Disaster Management Cycle should address issues relevant to all phases of the disaster cycle: preparedness, response, recovery, rebuilding, prevention, mitigation. Reading about similar experiences of other institutions cannot only help to avoid making the same mistake but can give an idea of what to expect after a disaster.

Yet, it should be realised that each collection, each building, each situation is unique and that every institution has to prepare for disasters with its own unique plan.

By and large, knowing how to react to a disaster is everyone's responsibility, but especially for those with public responsibility. Consequently, it should be the prime concern of any archivists to develop a way of preventing disaster and carry it out; even if it is not perfect, it can reduce the damage to his precious collections. Besides, thought and preparation will eliminate panic and ensure that proper decisions will be made and carried out step-by-step. This is very important with objects made of paper whether they are framed or unframed works of art, documents, records, photographs or books. Nevertheless, the safety of the employees must come first before proceeding to salvage any objects (Bishop Museum website). The *Memory of the World Programme* gives the following general advice (Brandt-Grau, 2000):

- be prepared for any type of disaster; contact and consult other institutions to share information and experience, and with a view to regional cooperation;
- take advantage of educational sessions, particularly disaster planning workshops and preparedness exercises;
- seek expert advice and help from the preservation offices of national institutions, members of standing committees, centres of professional organisations and their technical committees.

Searching for literature on disaster amounts to an overload of all kinds of publications, from a serious discourse to a bedside novel. It is best to be very critical and discriminating. Many institutions safeguarding their cultural heritage design and publish their own disaster preparedness plan. In most western countries plans are intended to prevent fire and water calamities . In addition, many regional and object-specific disaster plans appear. However, roughly all plans relate to situations in non-tropical countries. Again, many books are available on natural disasters. Not much has appeared in print on the effects of natural disasters, apart from floods, on archives, libraries or museums. Another omission is the literature on neglect. True, many books deal with issues of theft as it affects institutions guarding cultural heritage, but very few dare to publish anything on neglect as nobody wants to wash their dirty linen in public.

Good, comprehensive, timely tools to answer disaster questions are few to non-existent. The internet, an endless source of information, has become one of the best reference tools available for questions relating to disasters and the authors give an extensive list of relevant websites (Musser et al., 1997). However, it should be noted that the addresses on the internet change very often and are thus quickly outdated.

Several bibliographies and databases are available on the internet, like the ones at the South-eastern Library Network (SOLINET) website, the International Strategy for Disaster Reduction (ISDR) website, the World Bank-DMF website, and the Natural Disaster Reference Database (NDRD) on the NASA-LTP website. According to Musser and Recupero (1997) disasters are also popular topics at the reference desk; check the websites of FEMA, US Geological Survey. The Natural Hazard Center in particular gives many more links. The Virginia Cooperative Extension publishes an 'After a Disaster' Series on their website on Safety, Food and Water, Coping with Stress, Cleaning, Insurance and Contracts, Landscape and Agriculture, Roof Repairs. Also check the websites of CoOL and Museum Security Network, a Dutch initiative from Ton Cremers.

For older literature on disasters see the bibliography in *Buchanan, 1988,* for more recent literature see the bibliographies by *Murray, 1994* and *Henry, 1997.* An early general title on disaster preparedness for archives is *Barton et al., 1985.* Although written for North American conditions, it is an efficient and effective planning manual for disasters – covering the many and varied aspects of contingency planning, and is clearly set out with lots of checklists for action.

For disaster preparedness in general see *Hughes, 1999; Kahn, 1998; McIntyre, 1996; Ogden, 1999.* For guidelines on disaster preparedness see *Murray, 1991; Fröjd et al., 1997; Thomas, 1987*. For handbooks or manuals see *Balloffet et al., 1992; Fortson, 1992; Huskamp Peterson, 1993; Morris, 1986; Trinkaus-Randall, 1995*. For other literature on disasters and disaster preparedness see *Banerjee, 1997; Ezennia, 1995; Kumekpor et al., 1994; Mathieson, 1986.*

Several aspects of disasters that are of interest to the archival world will be discussed below. Fire and water cause the most recurrent damage to an archival building. Some of the measures to prevent such catastrophes will be reviewed. Disaster planning is a fundamental precaution no archive can do without. Such a programme should consist of prevention, preparedness, response and recovery. Commonly disasters are divided into natural disasters and man-made disasters. The following disasters are looked upon as natural disasters: tropical cyclones, forest fires, earthquakes, volcanoes, floods, and landslides. Some of these can also be caused by human behaviour e.g. forest fires or floodings due to deforestation. War, theft, neglect and vandalism are considered the major man-made disasters. To predict, to prevent and to prepare for all these calamities that can affect archives, libraries and museums it is imperative that work is undertaken on a global scale. Some of the programmes in international cooperation are mentioned in the last chapter.

6.2 Disaster Planning

Disasters are inevitable, but deaths from disasters are not. The challenge is to minimise their impact, to predict or even to prevent them. Disasters have a powerful and growing effect on the world. Yet there is little or no comprehension of their nature and scale, and the degree of suffering they inflict (*IFRC, 2001*).

Most of the time a library or an archive disaster is an unexpected event, which puts collections at risk. No institution can be excluded from or is immune to the possibility. Disaster planning, or counter disaster planning as it is sometimes called, is a matter of basic security for libraries and archives, their staff and their collections. It is considered to be an essential part of any preservation programme to be implemented by all archives, libraries and museums. A formal written plan enables an institution to respond efficiently and quickly to an emergency, and to minimise damage to the building and its contents (Brandt-Grau, 2000).

It is common knowledge that too few institutions have an up-to-date disaster plan. Sensible prevention is the backbone of disaster preparedness. By developing such a plan, however, archivists are not only better prepared to cope with an emergency, they are able to eliminate many potential hazards through the process of assessing the situation, the collections, and the repository both internally and externally (Trinkaus-Randall, 1995).

A counter disaster plan is little more than common sense – it is a document, which describes the procedures devised to prevent and prepare for disasters, and those proposed to recover from disasters when they occur. The responsibility for performing these tasks is allocated to various staff members. After the plan is ready and implemented it needs to be maintained regularly. It is of major importance that the layout of the plan is very clear and explained step by step (Lyall, 1997).

It is also important to note that the disaster terminology can be confusing. In the view of NASA, preparedness refers to the activities, programmes and systems developed prior to an emergency; response refers to organisations that are responsible for taking actions before, during and after the onset of a major disaster that will end the emergency and limit damage; recovery refers to programmes that provide longer-term assistance; mitigation refers to the physical preparations prior to a disaster. Thus in the production of a disaster plan several phases can be distinguished:

- Prevention;
- Preparedness;
- Response;
- Recovery.

In the outline of the plan there is recommended action for all four phases, but prevention is the best protection against disaster, natural or man-made (Brandt-Grau, 2000).

Today, all kinds of means are available to prepare properly for any disaster, man-made or natural. At the NASA-LTP website many organisations are listed that concern themselves with disasters in some way, among them relief agencies, research institutions and disaster management programmes. Together they publish a huge amount of advice on all conceivable disasters and many of them are accessible free on the internet. The conservation-related websites of NARA, SOLINET, CoOL and even FEMA should also be checked.

An overwhelming number of articles and books have been published on disaster planning. Indeed, so much has been written that most conservators do not know where to start. Unfortunately, the majority of the literature covers the situation in industrialised countries. For bibliographies see *Fortson, 1992,* which includes literature on recovery, and the bibliography published by Archives Library and Information Center Bibliography (Churchville, 1990). A recent volume of the *Journal of the American Institute for Conservation* is entirely dedicated to disaster preparedness, response and recovery (JAIC, 2000). In addition to the literature mentioned in the introduction of this chapter see *Barton et al., 1985; Buchanan, 1988; Dorge et al., 1999; Fakhfakh, 1995; Fox, 1996 and 2000; James, 1994; Lyall, 1995; Kenjo, 1997 and 2000; Obokoh, 1989; Shukor, 1995; Smithsonian Institute Office of Risk Management, 1993.* For disaster planning especially in Africa see *Alegbeleye, 1993* and for staff management during a disaster see *Reinsch, 1993.*

6.2.1 Prevention

The basic intention of prevention is to identify and minimise the risks posed by the building, its equipment and fittings, and the natural hazards of the area. This involves building inspection, routine housekeeping and maintenance measures, making security copies of vital records and storing them off-site, and providing uninterrupted power supply for computers, comprehensive insurance, etc. (Brandt-Grau, 2000).

A case study on managing disaster risk in Mexico shows that, despite the frequency with which a variety of natural disasters strike, the Mexicans invest inadequately in mitigation efforts. In addition, insufficient funds are set aside to pay for relief and reconstruction efforts. As a result, when a disaster occurs, the government is often forced to use funds that had been allocated to other programmes, disrupting the operations of those programmes. The effect is a reduction in growth and the derailment of important development efforts (Kreimer et al., 1999).

Funding disaster control can be split in two areas of expenditure; one area is associated with providing protection through preventive measures and another is associated with reacting to an incident (Fröjd et al., 1997).

As stated by the World Bank's Disaster Management Facility the three main components of effective disaster risk management are risk identification, risk reduction, and risk financing and transfer. Numerous economic factors are involved when disaster strikes in developing countries. The World Bank looks at strategies for developing countries to share and transfer disaster risk more effectively from the angles of risk and insurance by the poor in developing countries (Kreimer et al., 2000).

Risk analysis or identification, which is part of a disaster plan, is a way to identify the risks of a specific location or building. The outcome of a disaster is basically twofold. A disaster can affect (Lyall, 1997):

- the institution only;
- the entire area in which the institution is located.

Risks can also be identified according to their probability and effect (Lyall, 1997). When the risks are fully analysed it is time to plan and eliminate as many risks as possible or at least start to reduce the impact. This process does not stop the event but merely eliminates or reduces the risks causing the disaster. As the world changes, so will the risks, they vary as conditions change (Lyall, 1997).

6.2.1.1 Buildings

The building, again, is the first line of defence in protecting the records. For that reason natural calamities such as storms, earthquakes and floods have to be taken into consideration in the design of a building (Gut, 1993). When contemplating a purpose-built repository, the archivist and architect ideally aim for a total preservation environment. An archive building should provide a secure, safe, and stable environment in which to store records. The choice of a site for an archive is influenced by all kinds of factors (see more in section on *Building*). The local climatic conditions of possible sites should be studied carefully and preference should be given to ones that are on high ground, have a cool and dry climate and are protected against sun and storms. The archive should not be placed close to dangerous industries and in areas that are frequently the scene of social unrest (Thomas, 1987). Geographic location, political situation, construction and condition of the building are the main factors, which influence the risk for the records. To turn a deaf ear to this piece of advice is asking for trouble.

At a world conference on Natural Hazards in February 2001 in Awaji, Japan the American delegate Shirley Mattingley argued that we should refer rather to killer-buildings instead of killer earthquakes. In her opinion it is the building, i.e. the construction of the building that is the main cause of the damage and not so much the earthquake itself. Her notion was shared by the delegates from India and Turkey, countries that were both victims of heavy earthquakes the year before. The point is that in general it is unclear whether the cause of hazards is natural or man-made. Deforestation of hillsides, bad building regulations, corrupt and irresponsible contractors, all cause much more damage than necessary (Lugt, 2001).

In the USA FEMA has published a brochure on multihazards and architecture. The document presents general background information about a variety of natural hazards, phenomena associated with fire, and an architectural concept called MPD, Multi Protection Design (FEMA, 1986).

The greatest potential for catastrophic loss of archival holdings comes from fire and water damage. No matter what has been done to ensure safety and to minimise environmental damage to the materials, all is for naught if through carelessness, accident, or natural causes a disaster strikes the repository (Trinkaus-Randell, 1995). Generally, the damage on records resulting from any disaster can be divided into four groups:

- water-related damage;
- fire-related damage;
- mechanical damage;
- chemical reactions.

For further reading see *Buchanan, 1988; Duchein, 1988; Fröjd et al., 1997; Ling, 1998; Tending, 1993; Thomas, 1987.*

6.2.1.2 Fire

Fire is regarded one of the biggest hazards for archives, museums and libraries and it occurs much more frequently than is often thought (Trinkaus-Randall, 1995). It can be caused by natural disasters as well as by humans. In case of war, terrorism or vandalism people purposely set fire to the repository but often it is just carelessness or neglect. Also during building activities there is a greater risk of fire. As in all archive buildings both people and records need to be protected against fire, although obviously not all materials kept in archives and libraries are equally susceptible to the flames and they all have different combustion characteristics (Sepilova et al., 1992). Arson is the single greatest cause of fires in records repositories throughout the United States. Because records centres represent government, they may be targets of deliberate or random violence. In some cases, the arsonist is known to staff. Arsonists may use whatever combustible material is to hand or they may collect combustible material and bring it to their chosen site (Read, 1994).

In essence storage rooms are just to store the archives. Equipment to make coffee, tea or even animal glue should be strictly forbidden on the premises. Additionally, portable electric heaters are common sources of fires. Their high electrical demand frequently overloads older wiring, and they are often accidentally left on after staff have gone home. Tea and coffeemakers must be restricted to break rooms or other areas away from records. Appliances must be checked frequently and, in particular, that they are unplugged at the end of the day. It is obvious that no open fire is allowed near archival and library collections (Nguyen Thi Tam, 1997). It is much better to have a separate kitchen for the staff, not too close to the storage rooms. Smoking in the storage rooms must be absolutely forbidden. Smoking within a records facility is unrelated to any function or operation, and literally brings fire into the building. Despite the popularity of this habit in many developing countries, smoking should be prohibited within all record centres and courthouses for the protection of records (Read, 1994). For many poor people the big metropolis ceaselessly offers a great attraction. Sometimes they build their shanties adjoining the archives building. They are unaware of fire safety rules and thus their presence forms a potential fire hazard. For the general good it is better to keep the grounds clear and put a fence round the archives.

Hot climates can influence the fire safety of an archive or library in all kinds of ways. For some time now it has been known that cellulose nitrate films are highly inflammable. These films decompose readily when heated above the ambient temperature. The heat produced by decomposition can raise the temperature to ignition point. Since the rate of chemical processes is stimulated by higher temperatures, cellulose nitrate films are a fire hazard when kept under tropical conditions, particularly when stored in a non-conditioned area (Sepilova et al., 1992).

In tropical climates rodent and insect populations are very diverse. Rodents can be destructive to electrical wiring. They gnaw the insulation and thus cause an electrical fire hazard. Termites can undermine the structure of a building. During a fire parts of a building can collapse because of this and the fire will spread through the entire building (Sepilova et al., 1992).

To prevent fire risk in general the staff must be disciplined. They must observe strict rules of conduct like no smoking in storage rooms and keeping fire-resistant doors closed at all times. The conservator should not take chances in the conservation laboratory. Dangerous chemicals, e.g. solvents used in the workshop, must be stored in explosion proof cabinets. In addition, it is advisable to set a limit to the amount of flammable and explosive chemicals kept in stock. In the tropics in particular the building and electrical equipment must be well maintained. Even the most substantial buildings will fall into disrepair if neglected in the tropics. Indirectly, neglect is a fire hazard because it can cause a short circuit or broken gas pipes (Rhys-Lewis, 2000b).

The methods of dealing with these dangers are (Duchein, 1988):

- architectural – building materials, design features, etc.
- technical – specific equipment for fire fighting, air-conditioning, fumigation, etc.
- regulatory – security rules, arrangements for supervisors, etc.
- fire prevention – smoke detector – elevators emergency electricity supply, etc.

In the design of a building there are always opportunities to build in fire precautions. The use of fire resistant building materials can delay the fire but so can the division of storage rooms into smaller compartments by fire resistant partitions and the isolation of the strong rooms from working areas (Duchein, 1988; Fröjd et al., 1997; Ling, 1998; Teuling, 1994).

The roofing must be constructed of fire resistant materials like tiles, slates or metal. Windows can be protected with tempered safety glass and fireproof shutters. Fireproof doors help to contain fire, smoke and soot. A building made of brick, stone or concrete is more fire resistant than a building made or partly made of wood. Fire retardants are often applied to wood. Some of the fire retardants in aquatic systems in use today are suspected of causing environmental problems. Polybrominated biphenyls (PBB) are forbidden in the USA and Switzerland (Groshart, C.P., 2000). The European Union has put the poly-brominated biphenyls on the list of highest hazardous substances.

Some HVAC (Heating, Ventilating, and Air Conditioning) systems offer the option of reverse fans to expel smoke from the building. If the building is in the vicinity of a forest fire, but not actually threatened, recirculated air only should be used or the intake of outside air should be reduced. It is advisable to use just HEPA-filters (High-Efficiency Particulate Air) (Trinkley, 2001).

Good house keeping in and around the building can prevent fire. In addition trained staff, and well-maintained safety systems are important to prevent fires in the storage rooms. All records should be boxed. This gives them some protection against fire and soot. Even the damage caused by large quantities of water can be reduced by boxing (Rhys-Lewis, 2000b).

The detection of fire at an early stage is very important. Ideally an automatic fire detection system should be set up with a sufficient number of detectors linked to a central monitoring panel. The International Council of Archives recommends smoke detectors instead of heat detectors, because smoke is produced at an early stage of the fire (Fröjd et al., 1997).

Files stored tightly in full boxes in open shelves fare better than those loosely stored. The tight files allow little oxygen in and often only exterior edges are charred. Files in filing cabinets are subject to very high temperatures. Text blocks will warp and plastic will melt (Trinkley, 2001).

After a fire there are several types of damage. Fire-related damage includes ashing, charring, melting, distortion, soot and smoke. The building and the collection will be partly water damaged. Fires can release dangerous materials as toxic chemicals, for instance PCB's (Polychlorinated Biphenyls), and asbestos. Most probably the electric lines will be damaged too. The floor will be covered in a mass of charred timbers, broken material and glass, and a soup of soot and water (Trinkley, 2001).

Some objects are not salvageable, no matter how sophisticated the conservation techniques. Some may be heavily charred, others lightly scorched, covered with soot, smelling of fire or have become very brittle. Smoke can leave a film and distinctive smell on the collection. This film is acidic in nature and causes discoloration, corrosion and overall damage. Cleaning of paper objects can be difficult due to its fragility. Employ a support and a screen in such cases to prevent damage to the documents (Trinkley, 2001).

In addition to charring of paper materials, the high temperatures will affect the cellulose structures causing brittleness even if they are not burnt. Soot will embed itself into the surface of paper and may carry with it residues from burnt plastic materials which are impossible to remove. Any burnt material is more fragile, especially if it is wet. Paper will burn at low temperatures and has a porous surface into which soot particles will embed themselves. At raised temperature and humidity, mould growth proceeds rapidly causing irreversible damage. Planning ahead will reduce these types of damage and limit the cost of recovery, as the Bishop Museum states on its website.

Fire fighting efforts may do considerable damage to records, from both the pressure and quantity of water used to extinguish a blaze, and at least part of the collection will be water damaged. Residues of certain chemical extinguishers can affect the materials too (Fröjd et al., 1997; Read, 1994; Trinkley, 2001). Books burn fairly slowly. Paper chars and crumbles when handled. Smoke and soot discolour books not otherwise affected. Microforms and audio-visual materials can be completely destroyed or damaged beyond repair (Brandt-Grau, 2000). For forest fires see section on *Natural Disasters – Forest Fires.*

Trinkley, who published more on disaster preparedness, wrote a practical introduction to all the major components of fire safety. It includes detailed explanations of all the fire detection mechanisms (alarms and smoke detectors) and suppression devices (sprinklers, portable extinguishers) typically used in repositories, with analysis of their features and benefits. Trinkley stresses the importance of conducting fire safety inspections and outlines the necessary elements of a fire safety programme (Trinkley, 1993a). For the devastating effects of a fire in a library see *Anonymous, 1988b; Fröjd et al., 1997* and *Sung, 1990.* For further reading see *GSA, 1977; Kraemer Koelier, 1960; Maxwell et al., 1999; Morris, 1979; National Archives of India, 1993; National Fire Protection Association, 1980; Thomas, 1987.*

6.2.1.2.1 Fire fighting methods

There are many ways of fighting a fire, one of them being the use of a fire extinguisher. Extinguishers are usually available in developing countries, yet maintenance is a serious problem. After several years their effectiveness is probably nil. To improve the fire safety regular fire fighting training and upgrading of simpler methods is necessary; a fire blanket alone is not enough (Rhys-Lewis, 1999 and 2000b). If there is no fire hydrant in close proximity of the building the creation of an alternative water source, like a pond or a well, including a pump could be a cheap solution (Trinkley, 2001). Sand may be an option too.

Over the years new fire fighting techniques and methods have been continuously developed. That is the main reason why fire safety of existing buildings often lags behind. Part of the problem might be solved by impregnating wooden structures with fire protective substances (Sepilova et al., 1992). Fire retardants should not be used indiscriminately as they can cause environmental problems. Care should be taken in their application, particularly because some substances are forbidden in several countries (Groshart, 2000).

It is common to divide the fire extinguishers into three groups

- automatic fire suppression systems;
- hand held portable fire extinguishers;
- water hose reels.

The automatic fire suppression system can be either water based, like the water-mist system and the sprinkler system, or gaseous based, like the carbon dioxide system and the now forbidden halon-gas system. Water-mist systems use a great deal less water by volume than e.g. sprinklers. They are probably the future of fire suppression for cultural institutions. The water-mist system has been tested on a stack arrangement similar to the rare book vaults in the Library of Congress. According to Nick Artim the test was very encouraging, demonstrating substantial fire suppression with a maximum of 10% of the water discharge which would occur in a normal sprinkler controlled fire (Atrim, 1995; Dorge, 1999). Sprinkler systems have been a subject of discussion among conservators for several years. Some are afraid of accidental discharge, others riposte that in the past thirty years there has been no sign of such an incident whatsoever. Damage to objects after fire brigade action with traditional hoses can be far worse, as sprinklers release only seventy litres of water a minute compared to several thousand litres from a fire hose. In general, water damage on wet records is easier to repair than fire-related damage (Ling, 1998; Fröjd et al., 1997). If the storage rooms cannot be compartmentalised, as a precautionary measure, the installation of a sprinkler system is advised. If sprinklers are not used the fire rating for walls and doors should be four hours, otherwise a two-hour period is suggested (Ling, 1998).

Amongst the gaseous-based systems halon-gas was widely used until recently. Today the gas is forbidden in many countries due to its damaging effect on the environment. Carbon dioxide is still in use in a few archives but only under very strict regulations. It is a very effective substitute for oxygen without which no fire can exist, but when people are trapped in the area where the gas has been released, they are bound to die from lack of oxygen. It is also difficult to deploy the gas efficiently in large areas (Fröjd et al., 1997).

Amongst the available hand held portable fire extinguishers not all are suitable for the use in archives. The ICA advises having both a carbon dioxide and a water extinguisher at each fire point. Carbon dioxide should, preferably, be used for fires caused by electrical malfunction. Experiments at the Dutch National Archives showed that carbon dioxide is ineffective on paper based fires. The ICA recommends one water extinguisher, holding twenty litres, for each two hundred meters of floor area with a minimum of two extinguishers on each floor. Foam and powder extinguishers are not recommended as the residue could affect archival materials (Fröjd et al., 1997).

The traditional water hose reels are employed to fight fires too large to handle with hand held extinguishers. The reels should be situated outside the storage room to reduce damage in case the water pipes burst. According to the ICA, all parts of the building should be no further than six meters away from a fully extended hose (Fröjd et al., 1997).

6.2.1.3 Water

Perhaps the second most common threat to archive holdings is water damage. Several precautions must be taken. In places where the soil is damp, cellars and basements can suffer from moisture penetration from below. Technical solutions for this problem, a technique called tanking include a waterproof membrane or a damp-proof course in the foundation of the wall (Ling, 1998). Storage rooms must not be located beneath kitchens and water-reservoirs and no sewage or water pipe should run through the storage room (Duchein, 1993).

The building must act as a natural protection for the collection against exterior water. But it can also be the cause of disaster; roofs, walls, doors, windows, cellars, gutters and drains can all be the immediate cause of the intrusion of water (Ling, 1998). The roof covering must, of course, be rainproof and tightly fixed, pitched roofs being preferred to flat roofs, and roof openings should be avoided. Doors and windows must be watertight and can be protected from heavy rain by shutters, porch roofs and external galleries. Gutters and drains become a hazard when they are not correctly maintained and cleaned on a regular basis (Duchein, 1993). Large trees that grow near buildings can become a particular nuisance, like some eucalypts that drop leaves, bark and twigs, thus blocking guttering and pipes. In addition, their roots can damage drainage systems. Internal drainpipes are a risk of leakage (Ling, 1998).

Water ingress is often due to bad quality plumbing or poor maintenance of the water installations. For this reason water-carrying installations should be inspected and maintained regularly. Strategically placed flow control valves can stop the flow quickly (Fröjd et al., 1997). Water pipes typically run throughout a building and may well be located directly over areas where records are stored. Any water from a leaking pipe will run to the lowest level in the building, making all areas beneath a leak susceptible to damage. It is essential to know where pipes run directly over stack areas (Read, 1994). See also section on *Building – Construction – Traditional Building*.

Disciplinary measures or rules of conduct are an essential part of the protection against water damage. Some are related to the maintenance of the building like the inspection of the roofs, gutters and drains, water pipes, cisterns, and frequent cleaning. Other measures are associated with staff behaviour like carefully turning off taps in all rooms and the closing of windows during periods of non-occupation (Duchein, 1993).

Books and paper generally become distorted when in touch with water . Text blocks become partially or completely detached from the binding due to different capacity for swelling. Water-soluble inks start to bleed and mould starts to develop within forty-eight hours, even sooner in warmer climates. Film emulsions will blister and lift from support surfaces (Buchanan, 1988; Waters, 1993).

Paper absorbs water at different rates depending on the age, condition and composition of the material. Generally speaking, books and manuscripts dated earlier than 1840 absorb water to an average of 80 % of their original weight. Modern books, other than those made of the most brittle paper, absorb to an average of 60 % of their original weight. Leather and parchment warp, wrinkle or shrink. The damage done to book covers may be irreparable. Water can cause gelatinisation of parchment (Brandt-Grau, 2000).

Installation of water detection alarm systems in the storage rooms will provide good protection against water damage. Some alarms are connected to a central monitored security facility, others are self-contained and will ring locally. A practical problem with the autonomous alarm system is that when the facility is closed there is nobody present to react to the alarm. Sally Buchanan describes the best locations for the water detection alarms (Buchanan, 1988).

It is proven that boxes provide a remarkable degree of protection against water (Fröjd et al., 1997). To stop initial damage shelves must be placed at least four inches off the floor (Duchein, 1993; Fortson, 1992; Read, 1994).). For the same reason collections stored temporarily must never be placed directly on the floor, they should at least be placed on a pallet (plastic, if possible) (Fortson, 1992).

Rolls of plastic sheeting should be kept handy to cover shelving and cabinets in the event of a leak. However, plastic sheeting must not be used as a permanent covering for records: it will prevent good air circulation and create a potential climate for mould (Read, 1994).

For water damage the RAMP study by Sally Buchanan is worth looking at, so is Judith Fortson's more recent How-to-do manual (Buchanan, 1988; Fortson, 1992). For salvage of water damaged materials see *Walsh, 1988* and *Walters, 1993*; see also *Moore, 1997* and *Thomas, 1987*. For a recent water-based disaster see *Ellis, 2000*. For water damage caused by natural disasters see section on *Natural Disasters – Tropical Cyclones* and *Natural Disasters – Floods*.

6.2.2 Preparedness

In this phase the archive is getting ready to cope with a disaster. It involves actions like development of a written plan, keeping this plan up-to-date and testing it, preparation and update of all kinds of relevant documentation, the establishment and training of an in-house disaster response team, distribution of the plan and documentation, and procedures to notify appropriate people (Brandt-Grau, 2000), (see also Godounou, 1999).

It goes without saying that training is essential, because the staff must know what to do or know where they can find material and information. A small stock of emergency materials and equipment should be held in readiness. In case of emergency recovery can start without delay (Fröjd et al., 1997; Dorge, 1999; Buchanan, 1988; Lyall, 1997).

A disaster plan is tailor-made. Every institution must develop their own plan. The geographical location, the size and nature of the collection and the building all have their influence on the plan and are unique for each institution. It can be helpful to read disaster plans from other archives or libraries. It is advisable to start with identifying procedures on prevention and preparedness which already exist. A disaster plan is complex; it must apply to a building, the people and collection in that building, and the equipment. Therefore it consists of several independent but interconnected smaller plans. It is best to prepare it with a team of staff members. An important part of a disaster plan is the allocation of tasks and responsibilities. The plan must be practical and the instructions must be short and clear. It must be stored in an obvious place (Buchanan, 1988; Fröjd et al., 1997; Dorge, 1999; Lyall, 1997).

A major part of the disaster plan consists of a list with addresses, names and telephone numbers. There must be lists of the disaster team, of staff, of suppliers, and of salvage firms. These lists as well as the instructions must be kept up-to-date.Prioritising is also part of the disaster plan. Commonly there is a lack of time and resources. Not every thing can, or needs to, be rescued. Some items can easily be replaced, others are rare or valuable. It is much better to decide beforehand which items have priority as in an emergency it is difficult to think clearly (Fortson, 1992).

6.2.3. Response

Response is the phase of the disaster plan when disaster actually strikes. This element covers the instructions for the immediate actions after a disaster (Buchanan, 1988). It covers, amongst others, assessment of what is being faced, gathering of the disaster team, alerting the emergency services, and the organisation of the recovery (Fröjd et al., 1997). It also copes with stabilisation of the building environment to prevent the growth of mould, preliminary assessment of the extent of the damage, photographing damaged materials for insurance claim purposes, the setup of an area for recording and packing material that requires freezing, and transport of water-damaged items to the nearest available freezing facility (Brandt-Grau, 2000).

FEMA developed very concise and useful emergency response and salvage wheels (FEMA, 1997).

6.2.4 Recovery

The phase during which everything is getting back to normal is called recovery. At this time the team has to carry out the programme to restore both the disaster site and the damaged materials, determine priorities for restoration work, develop a phased conservation programme, contact insurers, replace treated material in the refurbished site, and finally analyse the disaster and improve the plan in the light of experience (Brandt-Grau, 2000). This part of the disaster plan will be the largest. It will contain a salvage technique for all varieties of media as well as the do's and don'ts for handling.

A lot has been said about recovery and the overall conclusion is that disasters have to be dealt with immediately. Delay increases the risk of losing part of the collection (Payne, 2000). This is especially true for water-related damage. The faster the corrective action, the better the result (Buchanan, 1988). Of course the materials need to be handled with care otherwise the objects will suffer additional damage instead of being rescued.

Attention must be paid to the hazards of the working environment. Ash, soot, mildew, dirt and mould all may cause ill health. Fire and earthquake damaged buildings are not healthy surroundings to work in. Precautionary measures must be taken for the safety of personnel by providing at least protective clothing and masks. It is important that no one is working alone in a damaged building and it is recommended that a buddy system is organised in order to alleviate much insecurity. Keep in touch with personnel through walkie-talkies and plot the work placement of personnel with a chart at the reference desk (Reinsch, 1993).

As a rule not much attention is paid to the needs and problems of the personnel at the time of recovery. The Getty Conservation Institute does bring this to the notice of conservators and distinguishes six stages of reaction that staff may experience after a disaster. Tensions and tempers may run high, but euphoria is also a possible reaction at a certain stage. It is important to schedule regular breaks, to provide food, organise a place to eat and rest, and have bathroom facilities at hand. When the staff have worked long hours, their fatigue will affect their work negatively (Dorge et al., 1999). Emotions and stress experienced during the recovery period after a disaster need to be managed. Physical and psychological problems at this stage should not be underestimated (Reinsch, 1993); (see also Payne, 2000).

It is obvious that, in particular, man-made disasters like war and terrorism, will have far-reaching consequences for the psychological health of the victims. Archiving the atrocities of war is not an easy task as John Dean found out during the recovery of the Tuol Sleng Archives after the war in Cambodia. There was a constant morbid and oppressive atmosphere in the room due to the character of the archives (Dean, 1999c).

Even theft or robbery in the archives, library or museum often have unforeseen consequences. Innocence, trust, collegiality and public confidence are all undermined and the psychological wounds can take a long time to heal depending on how quickly the crime is resolved. This is even more marked when the thief is a museum employee (Sozanski, 1999).

Lessons learned from a retrieval operation after an occupation are that identification and documentation of the collection are very important for recovery. Objects that are properly packed or boxed are safer when they are moved in the event of looting (Norman, 2000).

For personal protective equipment and measures during fire-related recovery see *Trinkley, 2001* and during water-related recovery see *Fortson, 1992.* For general health and safety see *Newman, 1989.* For further reading see *Barton, 1989; Cunha, 1992; Smith, 1992b; IFRC, 1993; Shapkina et al., 1992.*

6.2.4.1 Water-related Recovery

The Bishop Museum in Hawaii advises that first and foremost every item must be immediately removed from the wet environment to a clean, dry room where the temperature and humidity are as low as possible, to prevent an outbreak of mould growth. This can best be achieved by fans, placed indirectly so as not to blow away loose papers or pages undergoing the drying process. Since relative humidity is frequently over 60%, dehumidifiers will assist greatly to create a drier environment. Raised, flat surfaces are needed on which to place damp, or sodden, materials. Paper towels can be used to absorb moisture readily and can be continually replaced. Always remove the wet absorbent materials from the drying area, so they do not add to the humidity of the room. If the materials have to be dried outside for lack of a clean, dry room, remember that prolonged exposure to direct sunlight may fade inks or pigments and accelerate the ageing of paper (Bishop Museum website).

In western countries water damaged books are often frozen to prevent mould growth and to stabilise wet material. The drying method used for frozen paper-based material is freeze-drying. This method has shown good results but is very expensive. If the equipment for freezing and freeze-drying is not available or if this system is too expensive, air-drying is the only reasonable solution (Buchanan 1988).

Air-drying is the oldest and most common method of dealing with wet books and records. It requires no special equipment but it is extremely labour intensive and can occupy a great deal of space. Due to distorted bindings and text blocks after drying most bound material needs rebinding. Single sheets often need flattening and rehousing (Buchanan, 1999). In general it is better to dry books very slowly and in the shade.

In most of the general literature on disaster planning a chapter on recovery is found. For further reading see *Buchanan, 1999; Kahn, 1994; Lundquist, 1986; McCleary, 1987; NAA, 2000; Rees et al., 2000*; *Walsh, 1988 and 1997; Waters, 1993.*

6.2.4.2 Fire-related Recovery

One of the most difficult parts of recovery after a fire is soot removal. The removal becomes more difficult when the layer is compacted through excessive handling or when an object has been subjected to high humidity conditions. Tests at the Royal Saskatchewan Museum show that some objects were more difficult to clean six weeks after the fire than objects cleaned within a week after the fire (Spafford-Ricci et al., 2000). Again it is best to take action after a disaster as soon as possible.

Paper materials can best be cleaned with a vacuum cleaner, fitted with a HEPA-filter, or by wiping them clean with a dry sponge. Be sure to keep the books tightly closed to prevent soot settling in between the leaves (Trinkley, 2001).

Several new cleaning methods for fire-damaged artefacts have been investigated. Atomic oxygen treatment has been tested on fire-damaged paintings. The method seems to have potential. The process is not intended to replace conventional techniques, but can be an additional conservation tool where conventional techniques have not been effective (Rutledge et al., 2000). So-called chemical sponges have also been analysed (Moffatt, 1992).

There are two commercial processes available to rid the fire-damaged artefacts of the odour inescapably left by a fire. However, neither the thermal deodorization nor the ozone treatment are acceptable for museum, library and archives collections. The first method uses high temperatures and causes premature ageing and brittleness. The second will cause leather to deteriorate, alter dyes, embrittle paper and fade inks. Small objects can be sealed in plastic bags with absorbents like baking soda, clay cat litter and activated carbon. Over time much of the smell will be absorbed. Generally, the sooner the soot is removed from the artefacts the sooner the odour disappears (Trinkley, 2001).

Much information on disaster recovery can be found on the internet. Check the websites of CoOL, where several bibliographies are found like the one published by SOLINET: Disaster Preparedness and Recovery: Selected Bibliography. Also the NEDCC website (Northeast Document Conservation Center) is full of practical information, including several technical leaflets on recovery. For recovery after an earthquake see *Kreimer, 1989.* Next to the literature already mentioned earlier, see for general literature on disaster recovery *Doig, 1997; NAA, 2000; NARA, n.d.; Rutledge et al., 2000; Schreider, 1998.*

6.3 Natural Disasters

6.3.1 Introduction

In many parts of the world, according to the ISDR, disasters caused by natural hazards such as earthquakes, floods, landslides, drought, wildfires, tropical cyclones and associated storm surges, tsunami and volcanic eruptions have exacted a heavy toll in terms of the loss of human lives and the destruction of economic and social infrastructure, not to mention the negative impact on already fragile ecosystems. The list goes on of disasters that are difficult to guard against except by taking preventive measures. Every year, treasures are destroyed by fire and extreme weather conditions (Shukor, 1995). Indeed, the period between 1960 and 2000 witnessed an exponential increase in the occurrence, severity and intensity of disasters, especially during the 1990s. For example, at the United Nations workshop on water-related disaster reduction, data was presented that floods had been increasing in severity (UNESCAP, 1990). The facts and figures from the International Federation of Red Cross and Red Crescent Societies (IFRC) confirm this massive and increasing scale of disasters. Some 250 million to 300 million people are affected annually, most of them in Asia. In 1991 and 1998, for example, Chinese flood victims accounted for more than half of the global total (IFRC, 2001). This trend poses a major threat to the planet and therefore needs to be addressed by the international community with a sense of urgency.

The World Bank finds that developing countries in particular have become increasingly vulnerable to natural disasters as a result of such factors as population growth and urbanisation (Anderson, 2001). *Table 1* shows that the effects of earthquakes are far more devastating in poor countries than in rich countries. Subsequently, there are also cultural changes that produce an increase in the magnitude of natural disasters. In earlier days people had a thorough knowledge of the natural conditions of the area they live in. They adopted a way of life that could cope with natural risks. Over the years much of this wisdom has vanished. People move around for a better economic future. Some go to the city where such knowledge is no longer needed. Others come to live in unfamiliar areas vulnerable to unfamiliar disasters and are unprepared for them. Continuing external changes are another problem. For instance, the people living along the Chao Phrarya River in Thailand failed to cope with changes in the drainage system around Bangkok and the global climate changes, because of divergent traditions and customs (UNESCAP, 1990). In India people behave the same way (Prakash, 1994). It is essential to pay attention to the traditional knowledge of building and construction of the particular location when choosing a site for a new archive (see also section on *Building – Traditional Building*). Nowadays, natural disaster risks maps are developed (UNESCAP, 1990). If available for the area such maps can give valuable additional information. Consequently, we have to bear in mind that the human factor, i.e. the social, political and economic environment, is as much a cause of disasters as the natural environment (Blaikie et al., 1994).

	Managua	California

Magnitude (Richter scale)	5.6	6.4
Destroyed area of intensity	100 km²	1,500 km²
Population	420000	7000000
Death	5,000 – 6,000	58 – 60
Injured	20000	2540

Table 1: *Earthquakes effects in Managua and California in 1972 (Kumekpor et al., 1989)*

While natural hazards will continue to occur, human action can either reduce or enhance the vulnerability of societies to these hazards. Using the forecasting and early warning systems is one way of preparing for natural disasters. Following regional disaster experiences during the past few decades governments decided there was need for a permanent regional mechanism to coordinate disaster management activities. They often cooperate with local universities or other scientific institutions. This way the centres are able to make an immediate and coordinated response to any disastrous event. What is more, they play an essential role in educating the local population and training the staff of different organisations. Electronic media like the internet, television and radio play an important role in the forecasting and warning systems. Television and radio are particularly vital in providing local information as well (Burton, n.d.). Many of the monitoring and early warning systems are based on remote sensing, especially on satellite observation. It is only through bilateral or multilateral cooperation that we can afford these very expensive and high-tech systems (see also section below on *International Cooperation*).

Some major forecasting and warning centres, global or regional, are:

- National Earthquake Information Centre (NEIC);
- National Hurricane Centre – Tropical Prediction Centre (NHC/TPC);
- Caribbean Disaster Emergency Response Agency (CDERA);
- Asian Disaster Reduction Centre (ADRC);
- Committee on Earth Observation Satellites (CEOS), Disaster Management Support Group (DMSG);
- Hazards Research Lab (HRL).

In short, natural disasters cannot be prevented, but measures can be taken to eliminate or reduce the possibility of trouble (Brandt-Grau, 2000).

Many useful and practical websites can be found on the internet on natural disasters, their prediction, response and recovery. At the very least, the websites from the Natural Hazards Center, CDERA and CARDIN (Caribbean Disaster Information Network) should be checked.

Much has been written about all kinds of natural disasters. For a selection of recent general literature see *Abbott, 2002; Alexander, 2000; Anonymous, 2001c; Bell, 1999; Bradford et al., 2001; Burton et al., 1993; Chapman, 1999; Davis, 2001; Ebert, 1997; Erickson, 2001; Godschalk, 1998; Harris, 1990; IDNDR, 1997; Ingleton, 1999; Junchaya, 1999; Kovach, 1995; Kreimer et al., 1991; Lewis, 1999; Martin, 1998; McCall et al., 1992; McCann et al., 1995; Mishra et al., 1993; Mitchell, 1999; Sinha, 1992; Smith, 2000; Varley, 1994.* Especially for Latin America see *Talero de Husain et al., 1996* and *Zavala et al., 1985.* For building on safety in disaster-prone areas see the bibliography by *Clayton et al., 1994* and *Coburn, 1995.* For the protection of (historical) buildings against natural disasters see *Nelson, 1991.* For early warning systems see *Burton, n.d.; Carrara et al., 1995; IDNDR, 1998; Oliver, 1989.*

For the rest there are numerous journals like the *Journal of Natural Disaster Science, Natural Disaster Studies, Natural Disaster Survey Report, Natural Disaster Reduction* and *Natural Disaster Science.*

The following natural disasters are discussed below: tropical cyclones, forest fires, earthquakes, volcanoes, floods and landslides.

6.3.2 Tropical cyclones

Tropical cyclones combine destructive winds with storm surges and exceptional levels of rainfall. The adjective ‘tropical’ is used for good reason, as one of the conditions necessary for a cyclone to develop into a natural disaster is that it has to be located at least 4 - 5 degrees latitude from the Equator. Tropical cyclone is the generic term used by the World Meteorological Organisation to define weather systems developing over tropical or subtropical waters in which winds exceed 34 knots or 63 km/h. An average cyclone can bring more than 250 millimetre of rain in less than a day and have wind velocities of 200 km/h. Tropical cyclones also have a definite organised surface circulation. In the Atlantic and Eastern Pacific they are called hurricanes, in the Western Pacific typhoons, in the Indian Ocean just cyclones and in Australia, Willy-Willy (Anonymous, 2001b).

Strangely enough cyclones can have positive effects too. In an old article Sugg discusses the drought-breaking effects of some tropical cyclones in the USA and tabulates which cyclones have been most beneficial in this respect (Sugg, 1968).

As a result of cyclones buildings and their contents are endangered, damaged by enormous wind-forces and storm surges, causing landslides and flooding. Public utilities like power lines, water and gas distribution lines, and drainage systems are subject to severe damage. Fallen trees and flying debris cause damage. Communication is difficult as telephone lines, radio and television antennae are blown down. Roads will be blocked by debris or fallen trees (Anonymous, 2001b).

The damage inflicted on objects after a cyclone consists mainly of water damage, mould and mechanical harm. Not all staff return after a cyclone, some are evacuated and others have important private problems to solve (Doig, 1997). There is also the psychological reaction after a disaster. Corbett writes: 'However, there was ample evidence of apathy resulting in further damage by rain during the weeks following the cyclone, and resulting unnecessary mould problems' (Corbett, 1974).

A low-lying coastal site is a bad choice for a repository. In the case of a small flat island country, subject to typhoons, the most suitable site for an archive building might be on the leeward side (Thomas, 1987). Historic buildings that are well maintained are more likely to survive a disaster (Nelson, 1991).

The roofing and drainage systems are very important. Pitched roofs and a good drainage system ensure a rapid removal of rain water. Cyclone shutters for all glassed areas will prevent broken glass from flying debris. Cyclone shutters look like garage roller doors. The external openings of mechanical and electrical plant rooms should be covered with cyclone dampers. Dampers seal all openings and reduce the pressure on the building. They look like columns of louvers. Each year before the cyclone season, the shutters and dampers must be inspected to be sure they work properly when necessary. After a cyclone warning it is important to inspect surroundings and remove all objects that might serve as airborne missiles. Shutters and dampers must be closed. Air-conditioning systems must be shut down so that in the case of fire the damage is not widespread (Ling, 1998).

The shelving units must be anchored securely to floor and ceiling. Boxes can reduce the damage enormously. Files should never be put on the floor, not even for a few days (Buchanan, 1988; Corbett, 1974; Fortson, 1992).

The International Committee of the Blue Shield (ICBS) planned a conference in 2001 for cultural institutes in the Caribbean and Central America. The conference was dedicated to preventive measures and the recovery after tropical cyclones (see ICBS website).

The websites of the Purdue University Weather Processor and the National Hurricane Center provide storm track charts and text-based tables for storms and plenty of links to satellite and radar imagery. There are many other publications on tropical cyclones, but they cover different aspects. Doehring and Williams analysed 181 tropical cyclones that have struck Florida since 1971; Shaw gives a history of tropical cyclones in the Central North Pacific and the Hawaiian Islands between 1832 – 1979; Pielke gives an overview of this meteorological phenomenon, including a tracking map of the tropical cyclones in the Atlantic Ocean and Gulf of Mexico from 1871 to 1989; Smithson discusses the changing impact of cyclones; Morris discusses a certain global model for early warning systems; Nelson deals with how to prepare, respond and recover adequately to protect historical buildings from the next disaster(Doehring et al., 1997; Morris, 1990; Nelson, 1991; Pielke, 1990; Shaw, 1981; Smithson, 1993). For the destructive force of a hurricane see *Corbett, 1974* and *Loose et al., 1992.* For buildings on an earthquake site see *Mayo, 1988* and *James Cook University of North Queensland, 1978.* For more on tropical cyclones see *Aarson, 1989; Anonymous, 1989b; Mathieson, 1983; Trinkley, 1993b.*

6.3.3 Forest fires

Fire is a complex phenomenon and, if encountered without adequate knowledge, can threaten an archives building, its holdings and surroundings. Fire is complex because it is highly variable in space and time. This variability is also seen in successive fires in an area – the fire regime – where the type, frequency, season and intensity of fire vary markedly. Much remains to be learnt about the effects of repeated fires (Earth and Atmospheric Science, Purdue University ESA website).

The interaction between people and nature is not without danger, be it in the USA where more than four out of five forest fires are started by people, according to FEMA, or Canada where people are responsible for starting two out of every three forest fires (Todd et al., n.d.). Forest fires can have several causes, one of them being lightning. Under extremely dry conditions forest fires are a potential hazard. The greatest danger associated with the Nigerian dry sandstorm, the *harmattan*, is the outbreak of fire. The dry and brittle nature of this weather pattern makes everything susceptible and the season rarely passes without reports of fire. Homes, markets, offices, schools, libraries and even vehicles have been destroyed, resulting in staggering losses of property and valuable documents (Ezennia, 1989).

Another cause of forest fires is the agricultural tradition of slash and burn. In slash and burn cultivation a field is cleared by felling trees and burning the bush; the ashes return nutrients to the soil. Fields are used only for several years and are then allowed to lie fallow for a number of years. This is the practice in certain sections of Nigeria. Besides slash and burn cultivation, hunting tribes burn bushes to aid hunting. In both cases, the uncontrolled practices have taken a heavy toll (Ezennia, 1989).

Much has changed in the field of fire fighting. Today, early detection is an important component in the total fire management system. For example, during the past 30 years air patrols have replaced lookouts as the main forest fire detection method and high altitude infrared detection systems offer a good solution to poor visibility (Kourtz, 1987). Spatial analysis is another forest fire preparedness planning method to prepare properly for a fire (Lee et al., 1989).

It is clear that buildings and equipment must provide the basic measures for protecting collections against fire (see also above section on *Disaster Planning – Prevention – Fire*). The first step is to make a safety zone around the building. For pines a safety zone of 100 feet is required at least, as a rule 50 feet is the minimum. All dead trees, plants and shrubs in this zone should be removed. The trees around the archives building should be spaced 30 feet apart and be pruned to 10 – 15 feet in height. Stone and gravel can be used as fireproof mulch around buildings. Some trees and plants resist fire better than others. Ice plant, aloe, currant, hedging rose, maple and poplar are more resistant than pine, fir or conifers (see also section on *Building*). Flammable materials like firewood must be stored more than 100 feet from the repository. A fire in a rural setting is often very hard to control. When the organisation is located in a wood far from fire stations or water supplies, it should be prepared to face the threat of forest fires. If there is no fire hydrant in close proximity to the building it is recommended that an alternative water source (with pump) is created, like a pond or a well. It is also necessary to make sure that emergency vehicles can reach the building (Trinkley, 2001).

As with other natural disasters, there are many websites on the internet on forest fires. The National Interagency Fire Center (NIFC) and the National Fire Plan websites are both US-based organisations and give a lot of useful information on wildland fire in general.

Hirsch and his colleagues compiled a bibliographic listing of about 2200 wildland-urban interface resource materials. They provide information on a diverse spectrum of topics related to fire management in the wildland-urban interface ranging from building materials and hazard reduction techniques to disaster management, politics, and sociological issues (Hirsch et al., n.d.).

For further reading on forest fires see *Dudley, 1997; Eberlee, 1998; Gold Coast Council, 1998; Johnson et al., 2001; Mansanet Terol, 1987; McCann et al., 1995; McKaige et al., 1997; Trinkley, 1993a and 2001; Whittall, 1992; Zweck, 1983.*

6.3.4 Earthquakes

An earthquake is a sudden, rapid motion of the earth caused by the breaking and shifting of rock beneath the earth surface. At any time of the year and at any time of the day or the night an earthquake can occur. Smaller earthquakes, the aftershocks, can follow the main shock. Aftershocks can occur in the first hours, days, weeks or even months after the quake. Throughout the world 70 to 75 damaging earthquakes occur each year. The strength of an earthquake can be measured by magnitude or intensity. The Richter scale measures the magnitude and the modified Mercalli scale measures the intensity. Where earthquakes have occurred in the past, they will happen again (CDERA web site).

It is possible to predict earthquakes but the residents have only several hours leeway. Advance preparation for the eventuality of an earthquake is much better than to start preparations after the warning (Fox, 1999). Earth scientists began recording earthquakes about 1880, but it was not until the 1940s that instruments were installed in buildings to measure their response to earthquakes. The number of instruments installed in structures increased in the 1950s and 1960s (Celebi et al., 1995a).

Today, many institutions and organisations are watching out for earthquakes. One of them is the US-based National Earthquake Information Center (NEIC). It operates a 24-hour-a-day service to determine the location and magnitude of significant earthquakes in the United States and around the world as rapidly and accurately as possible. Every day the systems become more sophisticated and are readjusted when necessary. One of those systems is the Global Seismic Hazard Assessment Programme (GSHAP) that was launched in 1992 by the International Lithosphere Programme (ILP) with the support of the International Council of Scientific Unions (ICSU). The GSHAP project, which was terminated in 1999, can still be accessed through the NEIC website, and gives maps and technical information on earthquakes worldwide (see McGruire et al., 1995).

Earthquake related hazards include: collapsing buildings and bridges, flying glass, disrupted utility services, fires, landslides, flash floods, falling rocks in the mountains and in low-lying coastal areas tsunamis, i.e. huge destructive ocean waves (CDERA website). The damage or collapse of buildings, as well as other structures causes the majority of deaths and injuries from earthquakes. These losses can be reduced through documenting and understanding how structures respond to earthquakes. Gaining such knowledge requires a long-term commitment because large devastating earthquakes occur at irregular and often long intervals. By monitoring how structures respond to earthquakes and applying the knowledge gained, scientists and engineers are improving the ability of structures to survive major earthquakes. This has led to many revisions and improvements in building codes. One of the results of seismological research was the flexible roof design (Celebi et al., 1995b). Another fact to emerge from the growing body of such records is that the movement close to an earthquake's source is much stronger than once thought (Celebi et al., 1995a).

First when planning an archives building, it is imperative to determine a site that is safe. Identifying the geological structure of the grounds before building is advised, as well as checking if the location is a potential landslide hazard. When building in an area that is prone to earthquakes it is necessary to use a construction that is seismic resistant, following the local seismic building standards and safe land use codes, if available. It is important to realise that when we cannot prevent an earthquake then the least we can do is learn from them in order to reduce future damage (see Anonymous, 1989c; Geis, 1988 and Joice, 2001).

Many adaptations to conventional buildings are possible to reduce the effects of an earthquake. However, it is not possible to build earthquake-proof constructions (Anony-mous, n.d., a). Adherence to building codes can reduce losses caused by an earthquake since they are the public's first line of defence against the effects of earthquakes (Celebi et al., 1995a). All parts of a building, situated in an earthquake prone area, should, in essence, be attached to each other. The whole building should be bolted to the foundation, as it is less likely to be severely damaged. The building must be designed to be flexible and should hold together when it is shaken from side to side, and up and down (Fortson, 1992).

Timber structures are considered the most earthquake resistant among traditional forms of architecture, provided their joints are sound and insects or fungi do not attack the timber. However, timber buildings are vulnerable to fires, which often follow earthquakes (Feilden, 1987). The Incas traditionally built their homes with very thick tapered walls. These structures could resist the worst of earthquakes and landslides. They also built a drainage system that stabilised the slopes against landslides (Fox, 1999). It is not necessarily expensive to build an earthquake-safe edifice. For example, the Anglo-Indian architect Laurie Baker chiefly uses local building materials, and cost and energy effective techniques to build shock safe dwellings (Hochschild, 2000; Kremp, 2001). Thus architectural decisions concerning site planning, building configuration, and other construction practices are crucial determinants in the overall performance of a building during an earthquake (AIA, 1992).

An older building may have later additions, which may be weaker than the original areas. The foundation must be checked for possible damage by termites. Buildings that are retrofitted and prepared for a possible earthquake and regularly maintained, are much more likely to survive with minimal damage (Nelson, 1991). Straps, cables and centre rods minimise the possibility of collapse while having a minimal impact on the historic building fabric (Tolles et al., 1996, 2000 a and 2000 b).

Inside the building electric cables, water lines and gas pipes should be fitted with devices that prevent breakage. High buildings' sprinklers and fire alarms can go off during an earthquake even if there is no fire. A dry pipe sprinkler system is preferable in a seismic active zone. Dangerous chemicals in the conservation room should be stored in special cupboards, which must be securely bolted to floors and walls (Cornu et al., 1991).

To prevent, or at least diminish, the earthquake effects several precautions can be taken in the storage room. Shelving may collapse and the contents be thrown on to the floor. Few books can withstand such treatment. Fire and water damage often result from seismic activity (Brandt-Grau, 2000). The storage units should be anchored securely to walls, floors and ceilings. Shelving units that are back-to-back should be bolted together. Back panels or X-bracing will make the shelving units more stable. In compact or moving shelving the materials are not thrown to the floor but people can be injured if the units move during a quake. An automatic aisle-locking device is the solution. Boxes protect files and books and reduce physical damage if they fall from the shelf. They also prevent unbound files from scattering over the floor. Drawers and doors of cabinets must be closed. Nylon webbing across the openings of shelving units can catch objects in case they slide outwards during an earthquake. Heavy objects must always be moved to lower shelves (Cornu et al., 1991; Fortson, 1992).

Relevant websites on earthquake disaster are the sites from CARDIN, CDERA, ADRC, USGS (United States Geological Survey).

For publications on the effects of earthquakes on archival institutions see *Ezennia, 1995; Lemmon, 1991* and *Ling, 1998*. For buildings and earthquakes see *AIA, 1992; California Seismic Safety Commission, 1992; International Institute of Seismology and Earthquake Engineering, 1992; Key, 1988; Kreimer, 1989; Norton, 1985; Stulz et al., 1976*. The coming ICOMOS (International Council on Monuments and Sites) -Proceedings of the *International conference on the seismic performance of traditional buildings. Istanbul, Turkey, Nov. 16 – 18, 2000* promises to be very interesting too. Naeim edited a seismic design handbook and Shelton published seismic safety standards for library shelving (Naeim, 1989; Shelton, 1990).

For general publications on earthquakes see *Agbabian et al., 1990 and 1991; Anonymous, n.d. a; Erickson, 2001; Harris, 1990; Jones et al., 1982; Kumekpor et al., 1994; McCann et al., 1995; Pichard, 1984; Tilling, 1991.*

6.3.5 Volcanoes

A volcano is a mountain or hill with an opening or vent from which volcanic materials such as lava, fragmented rocks or gases are ejected during an eruption.

A recent count indicates that in the past 10,000 years 1511 volcanoes have erupted in about 60 countries. Volcanoes are located in specific parts of the world, most of them being found on plate boundaries. Volcanoes are formed in subduction zones, spreading zones and hotspots (Simpkin, 1994). Japan and Indonesia are the major areas in the world of active volcanoes, followed by the USA. Since 1980, as many as five volcanoes have erupted each year in the United States (FEMA website).

A volcanic eruption can directly or indirectly be the cause of all kinds of hazards (CDERA web site):

- blasted projectiles. The projectiles can damage buildings, sometimes being hot and starting fires.
- mud flows. Volcanic rock and debris can mix with lakes and form a near solid flow that swallows up everything it encounters. Mudflows are also called *lahars*.
- pyroclastic flows and ashfalls. These flows are mixtures of hot gases, ashes, small fragments of rocks, and pumice. They can move with a speed of more than 100 km/h and cause lung problems and skin burns. Buildings can easily catch fire, and heavy ashes will damage a flat or low-pitched roof.
- gases. Gases can be harmful to the inhabitants.
- lava flows. Lava flows are very dangerous flows of extremely hot molten rock. They can destroy everything they encounter.
- local earthquakes.
- tsunamis. Tsunamis is Japanese for tidal wave.

Many websites pay attention to volcanoes and current volcanic activity. The volcanologist François Beauducel, from Guadeloupe published a bibliography on the Indonesian Merapi volcano and included links to specialised journals. The sites of the United States Geological Survey (USGS) that host several observatories such as the Hawaiian Volcano Observatory and the Cascades Volcano Observatories are especially worthwhile. Also see the volcano pages at the sites of the Michigan Technological University (Geological and Engineering Sciences), The Electronic Volcano hosted by Dartmouth College, the Volcano World, Smithsonian's Global Volcanism Program, and CDERA.

In contrast to the amount of general literature on volcanoes no references could be found on preservation in archives, museums or libraries, and volcanic hazards. For further reading see *Chester, 1993; Erickson, 2001; Gandru, 1997; Hall, 1991; Harris, 1990; McCann et al., 1995; Sigurdsson et al., 1999; Tazieff et al., 1990.*

6.3.6 Floods

Of all the natural hazards capable of producing a disaster, a flood is by far the most common in causing loss of life, human suffering, inconvenience and widespread damage to buildings, structures, crops and infrastructure (Anonymous, n.d., b).

A flood is an abnormal rise of the water level of the sea or rivers lakes. Floodwater can be deceptively strong. Fresh water moving at 4 mph (6,4 km/h), a brisk walking pace, exerts a force of about 66 pounds on each square foot (29,7 kg / 0,3 m^2) on anything it encounters. Double the water speed to 8 mph (12 km/h) and the force rises to about 264 pounds per square foot (119 kg / 0,3 m^2). That is enough force to force a car or lift a truck off a flooded road if water reaches door level (Disaster Relief, n.d.).

Floods can be caused by heavy rainfall e.g. after a cyclone, dam failures, storm surges and tsunamis. A flood may be a natural phenomenon, but its effects are often exacerbated, perhaps even caused, by unwise activities. For instance, people increase their susceptibility to flooding when they live in low-lying coastal areas, occupy gully banks, live in the flood plain of major rivers or reside in the lower sections of closed limestone valleys. Such risks could be minimised by identifying such areas via a Flood Mapping Programme, learning the flood history of the area from older residents and respecting the natural water courses (Anonymous, n.d., b).

Another major cause of flooding is blocked drainage. During periods of heavy rainfall the refuse that blocks the drains has a damming effect and prevents the water from flowing freely, thus creating overflows and ultimately giving rise to flooding. Deforestation can be another well-known reason for floods. Without the tree root system the rainwater runs freely down the slopes carrying everything, including soil and debris with it (Anonymous, n.d., b).

Flood mitigation measures in general deal with two main areas: control of the river and control over the land, including land use policies. Control over the river includes measures like channel improvement and the construction of reservoirs to store excess amounts of water. Control over land includes the construction of terraces and reforestation. These are just a few of the possible measures (CDERA website). The only totally effective protection against flooding caused by a river overflowing is to choose a site that is sufficiently high up to rule out this danger (Duchein, 1988).

At a workshop of the UN Economic and Social Commission for Asia and the Pacific (UNESCAP) at Bangkok in 1991 a delegate noted that 80% of all victims of water-related disasters live in Bangladesh, China or India. It appears that the low-income countries are the worst effected by flood disasters. It also became clear that most flood disasters victims live in rural areas and belong to the poorest section of the population (UNESCAP, 1990).

Preparing for a disaster is the best defence. Thus, when choosing a site for an archive, library or museum it is important to investigate the risk of a flood. The building itself requires a structure that can withstand water pressure or the velocity of flowing water. Proper anchorage of the building prevents floatation of the foundation. In several countries traditional houses are built on poles to diminish the damage of flooding. For institutions of cultural heritage the elevation of the basement may be a solution (CDERA website). Needless to say that the roof is important to prevent invasion of water (see section on *Damage – Water)*. Roof coverings must be able to resist heavy rainfall and the covering should be fixed tightly so that the wind is not able to tear it off. Flat roofs and skylights are a hazard, as are walls made of non-waterproof materials e.g. porous stone. A double thick wall with a void between them is advisable in flood-prone areas. All openings in the walls like doors, windows, vents, air holes, etc. are a risk. They must be watertight and shutters are a good protection against heavy rain. All windows must be placed well above the ground level (Duchein, 1993). Metal flood shields bolted into place will reduce water penetration through doors and windows, alternatively old sandbags or sheet metal coverings can be used (Fortson, 1992). The sandbag has a modern version: the water absorbent cushion. It absorbs the water and when swollen acts as a sandbag. After the disaster checks must be made for water accumulation in hidden areas like attics, false ceilings and compact shelving. Water can also damage the fire detection or fire suppressing systems (Fortson 1992).

Alarms can be installed to detect water in storage rooms water. They can be connected to a central response facility but if that is not possible self-contained units last up to 72 hours. Archival boxes, again, are a good protection for paper and books. Most boxes resist water and give some protection even when the water is contaminated with salt or other deposits of floodwater. As mentioned before *(*see section on *Damage – Water)* shelves must be at least four inches off the floor. Collections stored temporarily must never be placed directly on the floor, but always on a pallet. If there is not enough time to move a collection out of a vulnerable area, the shelving units should be covered with plastic sheets. They must not be covered longer than 48 hours and they should be checked every 12 hours for mildew. Always keep a supply of plastic sheets, heavy-duty tape and scissors in the storage rooms ready for use (Fortson, 1992).

The disastrous flood in Florence in 1966 severely damaged the holdings of the National Library. However, it also brought the concept of the conservation of library materials to the attention of the library public (Lan, 1990). The river water, channelled through narrow streets, travelled at up to 80 miles per hour and poured into Italy's National Library, drenching thousands of manuscripts (Nelson 1991). The 1997 flood in Poland affected about 80 libraries and destroyed around 300,000 volumes, the value of which is estimated at US $700,000. On top of that, the material losses in buildings and furnishings are estimated at US $1 million (Wolosz, 1999).

Water-related natural disasters bring confusion and destruction to a large segment of the community. This complicates the recovery. Staff may have other problems at home, lack of assistance from local authorities or shortage of supplies (Fortson, 1992).

Today the effects of water on documents are well known. Seawater is more damaging than fresh water due to the corrosive effects of sea salt. Flood water can be polluted and can cause particular damage to paper (see section on *Damage – Water*). Paper and books may also be covered with mud and dirt (Duchein, 1993; Waters, 1993). For the recovery of wet paper and books see section on *Disaster Preparedness – Recovery.* Audio-visual materials, photographs, microforms, magnetic media and other discs, are also vulnerable to water, and the damage depends on the type of the material, the length of exposure to water, its temperature, etc. (Brandt-Grau, 2000).

For websites on water-related disasters see Dartmouth Flood Observatory, Flood Hazard Research Centre (FHRC), International Tsunami Information Centre (ITIC).

An online bibliography on floods called *El Niño and flooding, a global resource* is published on the website of the Center for Ocean and Atmospheric Prediction Studies.

For further reading see *Anonymous, 1992; Corning Museum of Glass, 1977; Ezennia, 1995; Lucchitta et al., 1999; McCann et al., 1995; Rees et al., 2000; UNESCAP, 1990; Wolosz, 1999.*

6.3.6.1 Tsunami

Tsunami is Japanese for a tidal wave and is considered a special kind of flood often caused by an earthquake. This wave can move over the ocean at a speed of 800 km/h. *Tsunamis* remain an ever-present threat to lives and property along the coasts of most oceans of the world.

Most of the websites on natural disasters will also cover floods. For information exclusively on tsunamis see the National Tsunami Hazard Mitigation Programme website hosted by the NOAA (National Oceanic and Atmospheric Administration), and the websites of the National Tidal Facility, the International Tsunami Information Center, Tsunami hosted by the Earth and Space Sciences at the University of Washington.

Tsunamis are studied closely; for more on this research see *Hebenstreit, 1999; Tinti, 1993.* For the history of the tsunamis in the Mediterranean Sea see *Soloviev, 2000.* Also check the coming *Proceedings of the Tsunami Hazard Mitigation Programme Review* and the *IUGG International Tsunami Symposium (ITS 2001) held at Seattle, Washington on 7–10 August, 2001.*

For particular information on building and design for *tsunamis* see National Tsunami Hazard Mitigation Program, 2001. For more on tsunamis see *Bernard, 1991; Keating et al., 2000; Tsuchiya et al., 1995; USGS, n.d.*

6.3.7 Landslides

A landslide is the transport of soil and rocks downhill as a secondary effect of earthquakes, tropical cyclones, heavy rainfall or volcanic eruptions. Landslides are a wide spread geological event. They may have a speed varying from 10 miles per hour (16 km/h) up to 35 miles per hour (56 km/h). The consistency of debris flow ranges from watery mud to thick, rocky mud that may carry large items like boulders, trees, and cars. Debris flows from many different sources can combine in channels and their destructive power may be greatly increased. Everything in the path of the landslide will suffer damage. It will destroy buildings, obstruct roads and waterways and break down communication lines. Floods can easily result from landslides. It is estimated that in the United States landslides annually claim from 25 to 50 casualties and cause up to US $2 billion in damage (FEMA website). At the end of December 2000 heavy rains led to terrible mudslides in Varagas, nearby Caracas, Venezuela killing 20,000 people.

General mitigation measures are good drainage systems, land reform by terracing, reforestation to prevent surface slips, and ground cover with grass or crops. Buildings, especially those with weak foundations, built on a steep slope or at the base of a steep slope are threatened by landslides (CDERA website).

The website of the National Landslide Information Center will give more specifics on US landslide events. Their Searchable National Landslide Information Database gives plenty of relevant literature. For more reading see *Cruden et al., 1997; Dikau, 1996; Erley, 1981; Keating et al., 2000; Mulder, 1991; Reeves, 1982; Slosson et al., 1992; Tianchi, 1990; Turner et al., 1996.*

6.4 Man-made Disasters

6.4.1 Introduction

Even if it is true that our libraries are overflowing with books, never before in the history of mankind has there been a century as destructive to books as the twentieth. Two world wars and numerous armed conflicts have exacted their toll, many totalitarian regimes have purged libraries of publications and what is left is often damaged by water or fire. Man has been more destructive to the cultural heritage than nature. Most of this damage is caused wilfully. To list all the causes of destruction and damage in a worldwide frequency and priority order is not feasible. Each region has its specific range of problems (Hoeven et al., 1996).

Record custodians may think of disasters as large, catastrophic events such as tornadoes or floods – dramatic natural events over which there is little, if any, control. Yet many disasters are events that only affect records within a single repository. But whether large or small, disasters can threaten the security of records. A single fire or flood can erase substantial portions of the unique recorded history of a community. To prepare for a disaster, we must first become aware of the potential dangers records face (Read, 1994).

ICOMOS, the international NGO dedicated to the conservation of the world's historic monuments and sites, has made its most recent report on Monuments and Sites in Danger available. From more than 60 countries the whole range of man-made dangers to cultural heritage is mapped, from the criminality of illegal excavations, the looting of churches for the international art trade, to the impacts of mass global tourism. The report is a first step toward recognising and recording monuments at risk, collecting information about the dangers they face, promoting action where catastrophes have already occurred, inspiring further commitments on national and international levels and providing an additional positive impulse for existing institutions already at work in this field (Bumbaru, 2000).

The following man-made disasters can be distinguished and will be briefly discussed below: war, theft; neglect and vandalism.

For further reading on security in general see *Agebunde, 1988; Baxi, 1974a; Liston, 1993; Menges, 1990; Nwamefor, 1974; Onadiran, 1986; Shepilova, 1992; Soete et al., 1999; Tefenra, 1986; Thapisa, 1982.*

6.4.2 War

In situations of war archives are exposed to severe risks. It would take a very long time to compile a list of all the libraries and archives destroyed or seriously damaged by acts of war, bombardment and fire, whether deliberate or accidental. No list has yet been drawn up of the holdings or collections already lost or endangered. The Library of Alexandria is probably the most famous historical example, but how many other known and unknown treasures have vanished in Constantinople, Warsaw, Florence, or more recently in Bucharest, Saint Petersburg and Sarajevo? Sadly the list cannot be closed. Within the framework of the Memory of the World Programme, H. van der Hoeven and J. van Albada attempted to list major disasters that have destroyed or caused irreparable damage during the 20th century to libraries and archives (Hoeven et al., 1996).

There are holdings dispersed following the accidental or deliberate displacement of archives and libraries. In the midst of armed struggle cultural heritage is liable to destruction. In isolated cases the records are actually the target of the conflict and are wilfully annihilated, as is illustrated by the destruction of the Records Office in Bo, Sierra Leone. In this case aggrieved citizens swooped on the record office since it was government property and thus represented the enemy (Alegbeleye, 1999; Fröjd, 1997). On the other hand, archives are a good source of useful information for the aggressor. In this instance they are often accidentally damaged in an attempt to hit other targets (Haspel, 1992).

Ideally the world population should consist only of convinced pacifists. Sadly the cruel reality disturbs this dream and teaches otherwise. War cannot be stopped but at least some precautions to mitigate the detrimental consequences can be taken. Once again the building itself is the first line of defence. The location of the archive should be as far as possible from strategic sites and town centres (Haspel, 1992). Building underground is another possibility to protect the collection against the effects of war (Haspel, 1992; Ling, 1998; Duchein, 1988). There are some disadvantages on building underground. It is very expensive and flood is a serious hazard (see also section on *Building – Underground Building*). Institutions that have actually built their repositories underground include Tel Aviv University (Israel), National Archives of Norway (Norway) and Diet Library (Japan). When building aboveground the walls should be thick enough to withstand a serious bomb attack and be without windows. Gas and electricity lines should be as far as possible from the archival materials. The building should be equipped with good fire fighting facilities (Haspel, 1992).

Institutions safeguarding cultural heritage are also known to come under attack from terrorists. In some of its consequences terrorism resembles war and many precautions against war also hold true for terrorism. In this case security is of the utmost importance (see also sections below on *Theft* and *Neglect and vandalism*).

During the planning and construction of the new Public Record Office in London much attention was paid to the security of the holdings. The intention was to prevent people gaining access at night and to prevent vehicles approaching the building too closely because of the possible threat of car bombs. A fence with only two entrances, one for cars and one for pedestrians encloses the site. Parking is not permitted within a specified distance to the office (Thomas, 1992).

Unfortunately the most recent terrorist attacks in the USA, the destruction of the Twin Towers of the World Trade Center in New York on September 11 2001, show that it is impossible to rule out a terrorist attack one hundred percent. Under these circumstances the FEMA has had to change the promise put forward in their fact sheet on terrorism that a terrorist attack in the USA remains possible, though is unlikely (FEMA website). The only way, it seems, to fight terrorism is to put much effort in taking precautionary measures.

Other preventive measures should be taken too. Inventories must be copied several times, for example on microfilm, and should be stored in different places, much as normal archival practice. The preparation of inventories that list priorities is very helpful, giving instructions on what to save first in case of danger. Many lessons can be learned from a retrieval operation after an incident. Identification and documentation of the collection are very important for recovery. Objects that are properly packed or boxed are safer. In a possible conflict zone boxing is more urgent as it prevents damage to the objects if they are looted or evacuated. The objects might be marked, possibly with UV-markers (Ultraviolet). This has the advantage that in the first instance the text is invisible to the naked eye. Whether this is proper preservation practice or not remains to be seen (Norman, 2000). In the worst case the holdings should be evacuated to a safe and secure place (Fröjd et al., 1997).

Naturally the International Committee of the Blue Shield (ICBS) has many programmes to protect cultural heritage in time of armed conflict, since this was its initial task (see also section on *International Cooperation – ICBS*). The Blue Shield is an important component of a Risk Preparedness Scheme, a coherent plan of action for collaboration among various international and regional agencies and organisations. It tested models for risk preparedness and Blue Shield operations will be customised in each country to reflect national and local, legal or juridical, organisational and technical practices and differences as well as cultural values and possible risks peculiar to the nation or the locality (ICOMOS-ICBS website).

It is obvious what an armed conflict can do to repositories. The damage to the objects is not all direct, much being caused by the indirect results of the fighting. Buildings are often damaged leaving the holdings almost unprotected to unwanted intruders and to the weather. Also a lot of harm is done due to fire and water-related damage as a result of clashes (Fröjd et al., 1997).

It is of the utmost importance that experiences continue to be shared, no matter how sad they are. The Zemaljski Muzej in Sarajevo, Bosnia-Herzegovina and the Tiroler Landesmuseum Ferdinandeum in Innsbruck, Austria together organised a congress about catastrophes and catastrophe management in April 2001. 125 Participants from 17 nations shared their unfortunate experiences in catastrophic situations. What most had in common was the fact that they were insufficiently prepared to deal with catastrophes in their museums. The conclusion was that it is important to exchange experiences to avoid making similar mistakes (Mader, 2001).

For some reason the consequences of the civil war for repositories in Nigeria in the 1960s appear to have been documented very well, see *Bankole, 1969; Bowden, 1974; Enu, 1970; Obi, 1971; Oluwakayode, 1972.* For further reading see *Atkins, 1993; Dean, 1999c; ICA, 1996; Mukimbiri, 1996; Peic et al., 1999; Redmond-Cooper, 2000; Varlamoff et al., 2000.*

6.4.3 Theft

Unfortunately, theft is a common threat to records. For the greater part the threat to collections in storage comes from internal theft, administrative loss and loss from external break-in. The staff, patrons or intruders may steal objects. Archival documents rarely attract thieves because of their financial value, nor because they contain confidential information. It is quite rare for documents to be stolen as a result of a break-in. When thefts do occur, they are usually carried out by readers of the reading rooms. In this respect, record offices should not be confused with museums (Duchein, 1988). Nonetheless, judging from the length of lists on book theft in the USA, theft is a popular occupation (Mason, 1975). The reason why not much is heard of these unfortunate events is that the managers and curators want to keep the name of the library in question out of the news. Book theft is simply not acknowledged. Part of this behaviour can be explained by the fear of contagion. Libraries are always nervous about revealing their vulnerability, but it is important to realise that book theft is a serious crime. Some stories are unbelievable and read like a real life thriller. Perhaps there is some wisdom in the inscription of a 13th century manuscript: ‘May he who steals you then be sent / A blow upon his fundament’ (see Reed, 1997).

The looting of collections by occupying forces is another consequence of war and terrorism. A side effect of warfare is the destruction of books used as fuel for cooking or as building material for recycling missing parts of historic buildings (Peic et al., 1999). In warfare the paper heritage is repeatedly reduced as available sources for fire, linings for damp floors, wrappings for market goods and even toilet paper (Rhys-Lewis, 1999).

Theft is not only a big problem for archives and libraries. Every day museum curators are offered stolen art and the illicit trade in non-western art especially is increasing hand over fist. As long as there is a ready market for illegal art in Europe and North America it is difficult for the developing countries to stop the theft of objects. In western countries a lot of money is spent on technical measures to protect the collection. But even if the government of a developing country can afford the most advanced security measures to prevent art from being taken out of the country, the attraction of easy money is likely to corrupt law enforcement agencies anyway. Only if public institutions refuse to buy illegal art will it be possible to stop illegal art dealing (Eyo, 1986).

Since 1997 the Object ID project has enabled museums and art-dealers to check whether an object is stolen or not before purchase. The goal of the programme is to realise an internationally accessible and efficient information system. An effective control system includes accurate documentation, identification and registration of stolen art. At the same time it is an international standard for describing cultural objects. It is promoted by major law enforcement agencies (FBI, Scotland Yard, Interpol), museums, cultural heritage institutions, art trade and art appraisal organisations, and insurance companies. In 1999 the Object ID project found a new home at the Council for the Prevention of Art Theft (CoPAT) (see Object ID website).

KIT Culture (Koninklijk Instituut voor de Tropen), in the Netherlands runs a programme to introduce a digital registration system in museums in developing countries. The aim is to curb illegal trade in cultural heritage. It has developed a museum documentation system for use in museums in fourteen countries in Africa, Asia and Latin America. In each museum a computer is installed with specially developed Object Identification (ID) software and a digital camera, the so-called KIT Object ID kit. One press of a button can inform Interpol and custom authorities that an object is missing. In this way, information travels faster than the stolen object (KIT Culture website).

There are a number of databases published on the internet that register stolen art and books, like the private Art Loss Register (ARL), the Red List of ICOM that concentrates on the looting of archaeological objects of Africa, and Interpol (see Portes, 1996 and UNESCO, 1995). Most of these can also be reached through the websites of Object-ID and Museum-Security Network.

The precautions to curb theft are often called security measures. Security measures can be high-tech like surveillance cameras and electronic locks, or low-tech like limited access to stack areas, bars on windows, traditional locks and gates, human guards and staff surveillance (Bellardo, 1995). Controlled access for current users ensures the availability of records for future generations (Read, 1994). A weak point in maintaining any security system is the malcontents who may seek retribution through theft, destruction, or wilful mishandling of collections (Anonymous, 1999).

In addition to technical methods of protection archives should issue security regulations. To enforce the rules, reading rooms and the entrance should be supervised. A registration procedure for visitors and general rules of conduct should be part of the security regulations. Warning signs might help too and are usually a good reminder of the rules. Experience teaches that storage rooms should not be accessible for all staff and strict adherence to procedures on key sign-out and sign-in for locked areas is necessary for proper security (Duchein, 1988; Ling, 1998; Storey et al., 1989; Thomas, 1987; Trinkaus-Randall, 1995).

There are also rules on how an archivist should handle the case of patron theft (Totka, 1993). Guards play an important role in maintaining the security of archives, libraries and museums but guards are not fully trained in security duties in all countries. If they are semi-literate it is possible that they are unable to identify passes and identity cards (Baxi, 1974a). The presence of trained security personnel on-site has made a real difference in a number of libraries – it has even saved lives (Soete, 1999).

The design of the building can help to reduce the danger of crime. The reading rooms should be designed in such a way that it is possible for the staff to supervise the public (Ling, 1998; Duchein, 1988). It should be remembered that all security measures in the building design are only as secure as the quality of the materials and building techniques. For example a lock is worthless when the materials used to construct the door, cabinet or window to which they are attached, are of inferior quality (Dixon, 1999).

Though published quite some time ago, it might still be interesting to read the issue of the UNESCO journal *Museum,* 1974 26(1), entirely dedicated to theft. A selected bibliography on art theft is available on the Museum Security website. On the same website you will find an electronic bibliography of URL's on Archaeology, Antiquities, Theft, and Looting, and The Looting Question Bibliography: Web and Literary Resources on the Archaeological Politics of Private Collecting, Commercial Treasure Hunting, Looting, and Professional Archaeology.

For security manuals see *Trinkaus-Randall, 1995* and *Fennelly, 1983* (technically out-dated). For more on all possible locks see *Dixon, 1999*. For further reading see *Allen, 1990* and *1994; Jackanicz, 1990; Lemmon, 1991; Moffet, 1988; Okotore, 1990; Okoye-Ikonta et al., 1981; Onadiran, 1988; Schmidt et al., 1996; Sozanski, 1999.*

6.4.4 Neglect and vandalism

Neglect is mostly caused by carelessness or a shortage of money but it can also be done on purpose. It covers several topics: the maintenance of the building, the handling of the objects by staff and patrons, and the pursuing of rules by staff (see also sections on *Building* and *Storage*). Other forms of neglect concern objects related to minorities, collections that have been removed by occupying forces as trophies or collections that have been removed to safer storage (Hoeven et al., 1996). These objects should be returned to their rightful custodians (see also section on *Preservation and Conservation – Preservation in Developing Countries – Artefacts From the Tropics*). In the meantime they must receive the same treatment in the storage room as the other objects in the collection (Nieç, 1998).

Vandalism is frequently a sign of revenge (Hasan, 1974). This is confirmed by the report of a vandal who slashed a Dutch Old Master painting with a knife in the Dordrechts Museum in 1989. The hooligan was said to be unemployed and disgruntled with the fact that foreigners are employed in Holland (Talley, 1989).

The Darwin facility of the Australian National Archives severely suffered from vandalism until a fence was erected around the perimeter of the site (Ling, 1998). The area around the building should also be well lit Trees and shrubs have the disadvantage that they can conceal people and can also be used to gain admittance to the building. Good fencing hinders trespassers and restricts unlawful transfer of property (Baxi, 1974a; Duchein, 1988; Ling, 1998; Teuling, 1994). Random patrols of the site in the silent hours by security personnel is advisable (Baxi, 1974a).

A survey of Indian museums from the early 1980s revealed that greater damage to objects was caused by neglect on the part of the curator than by any other agency (Agrawal, 1982b). Through proper training and education these problems could, at least partly, be prevented.

Most of the websites mentioned under *War* and *Theft* will have some information on neglect and vandalism.

6.5 International Cooperation

Many high-tech systems can only be realised through international cooperation. They contribute considerably to disaster mitigation worldwide by integration with conventional disaster prevention systems.

6.5.1 WMO

The World Meteorological Organization (WMO) has been a specialised agency of the United Nations since 1951. The purposes of the WMO are to facilitate international cooperation in the establishment of networks of stations for making meteorological, hydrological and other observations; and to promote the rapid exchange of meteorological information, the standardisation of meteorological observation and the uniform publication of observations and statistics. The World Weather Watch (WWW) is the backbone of the WMO's activities. WWW offers up to date worldwide weather information. The Tropical Cyclone Programme (TCP) is grouped under the WWW umbrella. The TCP, which contributes substantially to the UN International Decade for Natural Disaster Reduction, is designed to assist more than 50 countries in areas vulnerable to tropical cyclones in order to minimise destruction and loss of life by improving forecasting and warning systems, and disaster preparedness measures. Part of the hydrology and water resources programme are specialised forecasts to aid communities and governments in flood prone areas. The Regional Programme, with offices for Africa, the Americas, the Caribbean, Asia and the Pacific, provides a regional focus for all other WMO programmes and contributes to their enhancement especially in new priority areas.

6.5.2 The Hague Protocol

A new 2nd Protocol to the 1954 Hague Convention on the Protection of Cultural Property in the Event of Armed Conflict was adopted by unanimous consensus on the evening of Friday 26 March 1999 in the Hague, the Netherlands. The new Protocol represents the greatest advance in international cultural protection for decades. The original 1954 Hague Convention to prevent great losses of important cultural property has failed over the past 45 years, especially in the sort of dirty armed conflicts such as civil wars that have been a constant feature of the post-war world.

One of the major advances is that since the signing in 1954 the Protocol has now been acted upon and implemented at last. There will be two-yearly meetings of the States Parties, and the States will elect a 12 member Committee for the Protection of Cultural Property in the Event of Armed Conflict. The Committee will have a duty to monitor and generally promote, and consider applications for both exceptional protection and financial assistance from a fund to be established under the Protocol. The International Committee of the Blue Shield (by name) and its constituent eminent professional organisations will have important advisory standing roles in relation to the Committee and meetings of States Parties and will be consulted on proposals for e.g. exceptional protection designation.

6.5.3 CARDIN

The Caribbean Disaster Information Network (CARDIN) was established in June 1999 to provide links with Caribbean disaster organisations, to widen the scope of the collection of disaster related information and to ensure improved access to such material. In collaboration with its partners it seeks to provide a new and dynamic approach to accessing and disseminating disaster related information in a manner that adequately prepares for and minimises the effect of disasters in the Caribbean Region. From January 2000 the CARDIN Newsletter has been published in English, French and Spanish. Many organisations benefit from its activities, like government agencies, planning units, statisticians, policy makers, researchers, and students. The network covers the English, Dutch, Spanish and French speaking Caribbean and is funded by the European Community Humanitarian Office (ECHO). The Library of the University of the West Indies at Mona has been selected as the focal point for disaster information in the Caribbean.

The Joint IFLA/ICA Committee on Preservation and Conservation for Africa (JICPA) has promoted the establishment of national committees. At least thirteen countries, including South Africa, Botswana, Kenya, and Nigeria, report having preservation committees. According to G.O.Alegbeleye only the South African libraries have disaster management programmes. He hopes that more African libraries will develop disaster management programmes in the future through information available to national committees (Alegbeleye, G., 1999).

6.5.4 ICBS

The Blue Shield is the cultural equivalent of the Red Cross. It is the symbol specified in the 1954 Hague Convention (see above) for marking cultural sites to give them protection from attack in the event of armed conflict. It is also the name of an international committee set up in 1996 to protect the world's cultural heritage threatened by wars and natural disasters.

The ICBS, the International Committee of the Blue Shield, is the standing emergency coordination and response committee of the four principal UNESCO-associated non-governmental professional bodies for the cultural property area, i.e. the International Council on Archives (ICA), International Federation of Library Associations and Institutions (IFLA), International Council of Museums (ICOM), and International Council on Monuments and Sites (ICOMOS). They work together to prepare for and respond to emergency situations that could affect cultural heritage and cover museums and archives, historic sites and libraries. They respect the following principles:

- joint actions;
- independence;
- neutrality;
- professionalism;
- respect of cultural identity;
- work on not-for-profit basis.

It is vital that the international initiative is taken up and supported by local initiatives. Blue Shield Committees are being formed in a number of countries. The work of the ICBS was recognised in the Second Protocol to the Hague Convention, agreed in April 1999 by 84 countries. This gives ICBS a new role, to advise the inter-governmental Committee for the Protection of Cultural Property in the Event of Armed Conflict.

6.5.5 IDNDR and ISDR

At the beginning of 1990 the United Nations (UN) launched the International Decade for Natural Disaster Reduction (IDNDR 1990 – 2000) to make people aware of how much they can do to make themselves safer from natural disaster. The UN programme has undoubtedly achieved much good, although it has had little impact on the average person and little effect on reducing the severity of disasters worldwide.

The last decade of the 20th century has seen a number of natural disasters. In the Asia/Pacific region alone there were major floods in Bangladesh and China, an extremely severe earthquake in Japan and devastating bush fires in Australia. In all of these cases there has been criticism of the adequacy of preparation and the effectiveness of responses. This view is supported by the conclusions reached at a mid-cycle review of the programme at a World Conference on Natural Disaster Reduction in Yokohama, Japan, 23 – 27 May 1994, attended by representatives from 155 countries (Lyall, 1997). Despite criticism, the programme is continuing. In 1999 the International Strategy for Disaster Reduction (ISDR) was adopted at the IDNDR Programme Forum as the successor arrangement to the IDNDR. It reaffirms the necessity for disaster reduction and risk management to become essential elements of government policies. The ISDR will strive towards enabling all societies to become resilient to the effects of natural hazards, in order to reduce human, economic and social losses. This vision will find its realisation by focusing on the following six objectives:

- increasing public awareness;
- obtaining commitment from public authorities;
- stimulating interdisciplinary and inter-sectoral partnership and expanding risk reduction networking at all levels;
- improving further the scientific knowledge of the causes of natural disasters and the effects of natural hazards and related technological and environmental disasters on societies;
- continuing international cooperation to reduce the impacts of El Niño and other climatic variables;
- strengthening disaster reduction capacities through Early Warning.

For more on IDNDR see *Ingleton, 1999.*

6.5.6 ECHO

Since 1994, the ECHO, the European Community Humanitarian Office, has been financing disaster prevention, mitigation and preparedness operations throughout the developing world, in response to the requests of NGOs, international organisations and universities/research institutes. Although ECHO's mandate is to provide and fund humanitarian aid, it does more than just that. It carries out studies, sets up coordination arrangements, promotes and coordinates disaster prevention measures by training specialists, strengthening institutions and running pilot micro-projects. ECHO also organises training programmes and raises public awareness about humanitarian issues in Europe and elsewhere.

Chapter 7 : Integrated Pest Management

7.1 Introduction

The number of harmful pests in the world is enormous. A small percentage of them are harmful to human beings and their stored goods. They correspond to several thousands of invertebrate pests like insects and mites, and with several dozen vertebrates like rodents, bats, and birds. All over the world people are fighting these pests but because of the climatic and socio-cultural circumstances the developing countries suffer the most. First of all there are many species that thrive excellently in a tropical climate and secondly there are fewer obstacles to stop them.

A pest infestation can have three major detrimental effects: pests can cause damage to objects, can cause damage to users and can scare users. Organic materials in general are very sensitive to pest infestation. Next to paper and books, natural history collections, previously damaged materials, textiles and ethnographic materials are under the greatest threat (Clareson, 1993).

Insects account for much loss and damage every year and are partly responsible for the slow erosion of our cultural heritage (Pinniger, 1994). No collection is safe from pests! Insects have time on their sides having been in existence much longer than mankind. Therefore they have had more time to develop into the creatures they have become. The benefit of time gives them the ability to adjust to practically every situation. So they grab every opportunity for involvement with natural disasters, changing climates and very poor circumstances. They have the drive and the power to adjust to every situation with a very strong will to survive. Due to the speed with which they multiply they can overtake almost everything. Therefore insects are very strong enemies (Plumbe, 1959b).

Most of the insect species likely to infest paper collections are attracted not by the paper itself but by size, adhesives, and starches, all of which are more easily digested than the cellulose that makes up paper. Some insects will also attack cellulose (i.e., paper and cardboard) and proteins (i.e., parchment and leather). Insect damage does not come solely from eating habits; collections are also damaged by tunnelling and nesting activities, and by bodily secretions (Lindblom Patkus, 1999).

Mould, another notorious archive peril, has developed a perfect symbiosis with nature and objects made of natural materials. Whatever the climatic circumstances the spores can survive: hot or cold, wet or dry. This ability to exist on almost any material characterizes micro organisms as primary agents of deterioration. They are simple-celled organisms that do not need energy from light for growth. The microscopic spores are produced in enormous quantities, are always present in the air, and spread via air currents. They are often water repellent and are resistant to desiccation (drying out). Micro organisms, like fungi, will damage the materials supporting them permanently; they will leave stains and decrease strength. The scattered spots known as foxing on paper prints or drawings is damage resulting from these growths. Only extreme cold and heat will destroy them (National Park Service, 1993).

Rodents can be another nuisance in archives, libraries and museums. They are relatively small, gnawing animals that belong to the vertebrate species, being an animal with a backbone or spinal column. A few, such as rats and mice, are common pests in urban and industrial sites. There are many other rodent species that can be considered pests in certain regions of the world or in certain instances. However, although they may occasionally become severe pests, none have the global distribution of the house mouse, the Norway rat and the roof rat (Rentokil website).

A variety of rodents attack binding materials, adhesives, and other substances in library and archival collections. Since some of them are attracted to the confined, dark places that abound in storage areas, and since many materials are handled infrequently, rodents may do significant damage before they are discovered (Lindblom Patkus, 1999). Archive materials may be eaten, soiled, stained and shredded (Brandt-Grau, 2000). Typical evidence of rodent damage in repositories is the teeth marks left in leather and vellum bindings. More will be lost due to contamination with droppings, urine or gnawing damage. The most serious risk is that their close association exposes man to many harmful diseases, some of which can be severe or even fatal (Rentokil website).

7.1.1 The Old Way

In previous centuries people always fought pests and developed a wide variety of solutions and eradication techniques. In a number of instances these provided only partial solutions, some were only effective for a short time and others were extremely poisonous to both man and his surroundings.

The enormous developments made in chemistry has given new powers to man's armament of protection of himself and his cultural properties against the ravages of insect pests. Even now commercials encourage the public to fear pests (those creepy crawly things) and look to the eliminator (a robo-pest terminator) for immediate, simple, and effective control. Each year millions of dollars are spent on over-the-counter products, professional services, and restricted use pesticides. And yet we still have pests. In fact, some experts suggest that we are doing little other than creating super-pests, with increasing resistance to more and more pesticides (Chicora, 1994).

Libraries and archives have traditionally relied on pesticides for routine pest prevention and response to observed infestation. Pesticides often do not prevent infestation, however, and application of them after the fact cannot correct the damage already done (Lindblom Patkus, 1999). Since ethylene oxide fell from favour at the end of the 1980s, there has been no fumigant suitable for use in libraries and archives that could control both micro organisms and insects. Thymol fumigation to control mould has been shown to do more harm than good, in the long run. The search for non-toxic substitutes for ethylene oxide, thymol and other familiar fumigants has continued at an accelerated pace since then, with some success (McCradey, 1991).

Environmental and health concerns have caused a radical change in the popular perception of chemical pest control methods. Governmental and environmental agencies seek to further limit the uses of chemicals in areas that have, till now, accepted them as routine treatments (Nicholson et al., 1996). Not only can pesticides pose health hazards to staff but they can actually damage the paper-based collections themselves too. The simple truth is that we need to change our way of dealing with pest problems. We need to use fewer chemicals, make sure the ones we do use are appropriate and that their application is correct, and select the least toxic of the various pesticides available. At the same time we need to pursue mechanical and cultural changes which build or starve pests out more aggressively, making museums, libraries, archives, and historic sites less attractive to things that destroy collections (Chicora, 1994).

7.1.2 The New Way

In the early 1980s, a number of trends emerged in museum pest management. While the conservators remained concerned about the damage that the creatures were doing to the collections, they started becoming equally concerned about the damage that pesticides might do to the historic materials. Also they became increasingly worried about the effect that toxic materials might have on health. Professionals started looking for a way to protect the collections against the pests, while minimizing exposure to toxic materials. Soon they stumbled on Integrated Pest Management (IPM), originally developed for the agricultural and urban pest management communities, and introduced the concept to archives, libraries and museums (Jessup, 2001).

The days that scores of institutions had a contract for monthly spraying should be over by now. The pest control operator came in like clockwork and sprayed here and there. The conservator relied entirely on the commercial company and on the operator (Chicora, 1994). Ten years after its introduction in conservation the emphasis in pest control had become totally on IPM (McCradey, 1991). The IPM approach relies primarily on non-chemical means (such as controlling climate, food sources, and building entry points) to prevent and manage pest infestation. Chemical treatments are used only in a crisis situation threatening rapid losses or when pests fail to succumb to more conservative methods (Lindblom Patkus, 1999).

Today IPM is the preferred method and many pest control firms are offering IPM services, although what they are sometimes offering is little more than the same old techniques, repackaged to give them glitz. A true IPM programme will concentrate on the least toxic approaches to pest control by integrating a variety of mechanical, cultural, biological, and (as a last resort) chemical controls (Chicora, 1994).

It is impossible to give a ready-to-use solution to any pest problem. The IPM approach depends on the local circumstances. Some of these circumstances are (Jessup, 2001):

- the climate;
- the conditions in the repositories;
- the surrounding;
- the kind of pests.

Modern preservation professionals recommend Integrated Pest Management and in most situations where IPM has been implemented, both pesticide use and pest problems have decreased dramatically (Mitchell, n.d.).

7.2 Integrated Pest Management

Dwight Isley provided the earliest record of the Integrated Pest Management concept as a formal agricultural practice. Isley's work began in the 1920s when he pioneered modern pest control by using principles of scouting, economic thresholds and trap crops along with insecticides to control boll weevil in Arkansas cotton. He studied the biology and ecology of the boll weevil and used this information in a pest management system. Despite Isley's innovative program, and other researchers' understanding of the potential problems with pesticides, IPM did not gain momentum until the late 1960s. Initially, progress in IPM was slow largely due to the abundance of inexpensive, effective, synthetic pesticides and limited knowledge of the long-term effects of pesticides on organisms and the environment. However, as use of these compounds increased and became widespread, several factors lead to serious negative impacts on farm profits and an increased interest in designing IPM programs. Three primary factors involved are pesticide resistance, effect of pesticides on non-target organisms and increased regulation. Together, the factors mentioned above have spurred on the urgency of developing IPM programs for effective and affordable pest management. New legislation was enacted and governmental agencies began playing more of an active role in promoting IPM within research and extension. In the 1970s a few pilot projects were sponsored which emphasized scouting to monitor pest population densities and advised the application of pesticides only when economically damaging pest levels (the economic threshold) had been reached. Now, however, the reduction of pesticide use is of prime importance along with profitability. The newer philosophy of IPM will have some of the same objectives as the traditional profitability approach, but will also include factors of social welfare and environmental sustainability (Northern States Conservation Center, 2000).

When in the early 1980s Integrated Pest Management was introduced to the field of conservation, the general IPM-idea was easily translated. Naturally the objects to be protected needed to be handled with more care than foodstuffs and some other chemicals were needed in diverse amounts. As IPM is an eco-system approach to dealing with pest problems, it has always been site specific and thus adaptable to any application. The details of the treatment might differ yet the IPM-philosophy stays the same. Benefits of IPM include (Mitchell, n.d.):

- better pest control;
- a safer and healthier workplace;
- lower costs because of pesticide use reduction;
- better public and occupant relations.

7.2.1 Prevention and Control

Any IPM programme designed for a sensitive setting, such as a library or archive, an historic, cultural, ethnographic, art or natural history museum, or an architectural treasure, must be aimed at prevention as well as control of pest problems. Museum professionals cannot wait until part of a valuable artefact or structure is in the stomach of an insect or rodent before reacting to a pest problem (Parker, 1993).

Effective IPM programs reduce pest survival through minimizing those elements essential for pest survival (e.g. food, moisture and habitat). Components of any IPM plan include monitoring and identification of the pest, inspection, habitat modification, good sanitation, treatment action, evaluation and education. These components are on going and cyclical. IPM aims to prevent pest problems from occurring while at the same time reducing the use of toxic materials that may adversely affect the environment and the materials being protected against pests (Jessup, 2001).

To put it in a more complex way: IPM means employing an integrated, innovative and environmentally compatible control technology, utilizing environmental management, biological control and public education, supplemented by the safe use of chemical control technology.

7.2.2 IPM and Building

There are many routes by which pests get into a cultural institution. First and foremost a building offers many gaps such as doors, windows and drains. Typical roots of infestation in museums are formed in preparatory work (especially in museums, which use insects to clean the bones of animal skeletons) and educational programs (from which insects often escape). Other prominent ways in which pests enter the building are during disasters and storms (see section on *Disaster Preparedness),* in returned loans and in roof spaces with nests (Clareson, 1993). Several architectural methods of pest protection are already available, especially in countries that have ample experience with termite infestation (see section on *Building*).

7.2.2.1 Inside the Building

An IPM programme will only be as strong as the commitment of those who implement it, and everyone in the institution is involved. The exact steps in implementing an IPM programme will vary between buildings, climate, objects, accessibility to the collection, condition of the collection, environment, surroundings on the building and is dependent on how the management organisation is structured, management styles, etc. (Mitchell, n.d.)

The building should be considered the first barrier to insect entry, and play an important part in integrated pest management. This means the building surroundings, layout and fabric, housekeeping and sanitation, fittings and structures. Vertebrates that may become pests can be controlled by measures similar to those used for insects. In sealing off openings it is advisable to first check if an animal is sealed in (Pearson, 1993b).

It is particularly important to develop strict procedures for dealing with newly acquired collections, since such collections have often been stored in attics or basements that are hospitable to pests (see also Hickin, 1971). These procedures include the following:

- examine incoming material immediately;
- remove all objects from storage or shipping enclosures;
- examine frame backings and mats, wrappings, and other accompanying materials;
- transfer materials to clean archival boxes;
- if possible, isolate rehoused, incoming materials in a space away from other collections
- throw the old boxes away unless they are archival quality and you are absolutely certain they are clean;
- process and place incoming material in its permanent enclosures promptly;
- place a tent or motel-type sticky trap on a sidewall inside each box to improve monitoring;
- vacuum materials thoroughly (assuming the objects are not deteriorated or fragile) through a nylon or other soft screen, using a high-filtration vacuum.

It is important to remember that collections themselves are not the only source of food for insects. Much precautionary and preventive action can be taken within the building itself. By optimising the natural use of the building archival pests can for a large part be prevented. Next to proper housekeeping and regular pest monitoring some points of special interest include the following:

- confine food consumption to a staff lounge; leftovers should be tightly sealed or removed;
- pay attention to the attraction of dead birds and/or abandoned birds nests to insects;
- remove the remains of insects;
- avoid placing plants and flowers inside the building which will encourage the presence of insects;
- check additional points of entry for insects such as inadequately sealed windows and doors, windows and doors that are left open routinely, cracks and crevices in walls or foundations, openings around pipes, vents and air ducts;
- check damp areas like pipes running, water fountains, custodial closets, climate-control equipment, standing water on a roof or in other locations to which insects are attracted;
- check small, dark, tight and undisturbed spaces where insects that threaten collections thrive;
- prevent accumulations of dust and dirt which help to provide a hospitable atmosphere for pests.

7.2.2.2 Outside the Building

- vegetation close to the building provides an excellent habitat for insects; a planting-free zone of at least 12 inches should be maintained around buildings;
- the area around foundations should be gravelled and graded away from a building to avoid basement flooding;
- maintain climate conditions recommended for the preservation of paper to help to control insect populations.

7.2.3 Integrated Pest Management - Outline

As Integrated Pest Management (IPM) largely depends on the local situation various models have been developed. For their own purposes the National Archives of the Netherlands developed an outline of an IPM programme as insects, rodents and micro-organisms continuously threaten the archives (ARA, 2000). The holdings of the National Archives are considered unique and very valuable so the tolerance for the presence of pests is very low.

Integrated Pest Management can generally be defined as the coordination of all available information on environmental conditions, in the broadest sense possible, and the knowledge of pest control. A good IPM programme is based on the use of minimal quantities of poisonous substances through integration of a combination of mechanical, cultural, biological and chemical elements. It is a management instrument, in which all strategies linked with infestation are brought together.

In essence IPM is all about the population dynamics of pest species. It is a process to determine WHERE, WHICH, HOW, WHY and WHAT should be done. At first certain questions need to be answered:

- is control needed at all and can it be justified?
- when is control needed?
- where is control needed?
- what kind of control is needed?

The whole system of IPM is build around these four questions and they should be carefully considered one by one.

After the first four questions (see above) have been answered, the next matters which need attention are:

- at what point has the infestation reached its extent?
- are the repositories constantly monitored to identify the pest species?
- once the pest has been identified, is sufficient information collected to understand their biology and life?
- when the proper pest control measures and methods are chosen and implemented, do they all fit into a well integrated programme?
- when the programme is well on its way is it evaluated continuously and adjusted if necessary?

Probably the most difficult step in the entire IPM programme is to determine the moment when an infestation has reached its limit and action is desirable. This implies the question how much damage to archival material is acceptable? Translating it to the pest itself – how many of a certain species are acceptable? This limit of acceptance may differ from repository to repository.

It is absolutely imperative to learn everything about the identified species in order to choose an appropriate treatment. Some of the questions which should be asked include the following:

- how do the pests come into the building?
- where is their breeding place?
- what do they eat?
- where do they hide?

For mechanical pest control the following actions are advised:

- use self-closing systems for the doors to the storage rooms;
- close all windows or apply 16 – 18 mesh netting in front of the windows;
- apply 16 – 18 mesh netting for all grids;
- eliminate all water and moisture problems;
- ensure that the climate in the storage rooms is stable;
- use outdoor lamps around the building to disturb the life pattern of pests;
- avoid flowers and decaying wood around the building.

For cultural pest control the following actions are advised:

- avoid all plants (green or dried) in the building, including the offices;
- eliminate food sources and allow no food in storage areas;
- improve good-housekeeping habits and take special care of floors and waste pipes.

It is essential that the different measures of control are integrated with one another. Every action whether mechanical, cultural or chemical should support other actions.

Monitoring for pests is a daily business for any serious archive. When signs of infestation are ascertained, monitoring must be intensified. This should take place around the source of the problems. Once control measures prove to be successful, the intensity of the monitoring can be brought back to the normal level. If control measures are without result the entire chosen IPM system should be adjusted. During the evaluation it should become clear where the IPM programme went wrong. Possibly restrained chemical control needs to be added to the programme. The use of chemicals is often restricted because of environmental and health laws. Only qualified people, usually a recognised firm, are allowed to use pesticides.

7.2.4 Literature

An enormous amount of literature has been published on Integrated Pest Management. Before the 1980s almost all the publications were directly or indirectly aimed at pest control in agriculture and urban sites. Today many journals are still dedicated solely to IPM in (tropical) agriculture or stored food stuffs. When IPM became popular in the field of conservation, many IPM publications appeared tailored to archives, libraries and museums. In fact, the books and articles are nearly countless.

CoOL publishes several bibliographies on pest management on their website, see *Sánchez Hernampérez, 2001; Jessup, 2001* and *SOLINET, 2000*. The best-known general books on IPM are *Florian, 1997; Harmon, 1993; Olkowski et al., 1991; Parker, 1988.* Other literature is *Baish, 1987b; Flint et al., 1981a; Hanlon et al., 1993; Mitchell, n.d.; Parker, 1987 and 1993; Trinkley, 1990; Valentin et al., 1997; Wearing, 1988.*

For pest control in the tropics see *Agrawal, 1985, 1989, 1991, 1993* and *1995; Agrawal et al., 1991; Anonymous, 1962; Aranyanak, 1988a and 1988b; Baynes-Cope et al., 1966; Ezennia, 1991; Florian, 1997; Garg et al., 1994; Kumar et al., 1999; More et al., 1975; Nair, 1974, 1993b and 1995; Nair et al., 1972; National Resource Institute, 1992; Quek et al., 1990.*

For a bibliography on (urban) pest control see *Ebeling, 1978.* A complete overview of most of the possible non-chemical methods of pest control can be found in *Wellheiser, 1992.* For a recent handbook on pest control see *Mallis, 1990.* Some older titles on pest control are *Anonymous, 1955; Baynes-Cope et al., 1966; Hickin, 1971b; Merton, 1956; Nair, 1978; Szent-Yvany, 1968; Rossman, 1935; Werner, 1968 and 1979; Winks et al., 1977; Wood, 1956.* Other more recent titles on (urban) pest control are *Ackery et al., 1999; Baynes-Cope et al., 1987; Bennett et al., 1986; Brandt, 1995; Brewer et al., 1996; Cunha, 1989; Duverne, 1998; Florian, 1987; Gilberg, 1991; Gilberg et al., 1992; Gupta, 1984; Hedges, 1994; Lifton, 1985; Mehrota, 1991; Pasquarelli, 1989; Pearson, 1993b and 1999; Pinniger, 1991, 1993 and 1994; Pinniger et al., 1994; Pinniger et al., 1998; Robinson et al., 1999; Sarkar, 1991; Stansfield, 1989; Stranger et al., 1992; Truman et al., 1988; Valentin et al., 1998; Ware, 1980;, Wildley, 1996; Williams et al., 1989; Wixed et al., 1997; Zaitseva, 1989.*

For literature on bio deterioration see *Anonymous, 1949; Aranyanak, 1988a and 1988b; Agrawal, 1985, 1989, 1991, 1993* and *1995; Agrawal et al., 1991; Barnes, 1984; Bravery, 1977; Ezennia, 1991; Garg et al., 1994; Hongsaprug, 1995; Kumar et al., 1999; More et al., 1975; Nair, 1974, 1977, 1993b and 1995; Nair et al., 1972; Nyuksha, 1980* and *1994; Singh, 1994; Tosho et al., 1993; Valentin, 1986; Walters et al., 1972; Wimaladasa, 1993.* For guidelines on prevention of bio deterioration see *Cumberland, 1991.*

Many electronic publications and other useful information can be downloaded from websites on IPM. It is good to keep in mind that commercial companies are very active in this field and that they do not always adhere to archival standards. Check the many links on IPM at the site of British Columbia Ministry of Water (Land and Air Protection, Pollution Prevention and Remediation Branch) and the websites of the (commercial) magazine Pest Control and Kansas State University, Research and Extension. The literature referred to in previous chapters is also relevant to this subject, for example the sections on *Preservation and Conservation – Traditional Preservation,* and part of the sections on *Building* and on *Storage.*

7.3 Pests

Almost one million animals are described world wide. It is assumed, however, that the actual number of species is ten times as high, and insects especially are present in incredible quantities. Three quarters of all animals are insects. Most of these insects are found in the tropical regions due to the high humidity and the abundance of food sources. In times of shortage animals tend to specialise and adapt to almost any situation, no matter how difficult. This is why the flora and fauna are so diverse, especially in the tropics. The likelihood that one of these numerous and highly specialised species will enter our collection is therefore very considerable (ARA, 2000).

As an IPM programme needs to know all about the pest, its habits, and the environment in which it thrives and survives, it is very information-intensive. Although it is impossible for any conservator to take endless biology classes, some basic information on the most frequent pests is essential. Below we will briefly pay attention to moulds, insects, rodents and other small pests.

7.3.1 Moulds

Mould is a type of fungus. While there are many varieties, it can generally be said that mould spores are particularly attracted to starches, glues, gelatine, and leather, including human skin. In order to thrive spores need, besides food, a high level of relative humidity, above 60%. They are in the air at all times. If they remain dormant they are not a problem, but when the right conditions occur they become active and, if unchecked, will destroy many types of archive (Ling, 1998). If temperature and relative humidity cannot be controlled within limits, efforts should be made to retard fungus growth by maintaining free circulation of air. This helps to prevent fluctuations in humidity and the consequent formation of pockets of air amenable to fungus growth. The first measures taken to prevent mould are to keep the air moving and the area clean (Kathpalia, 1973).

Excessive heat, poor air circulation, and relative humidity above 65% provide a suitable climate for mould growth. High humidity is especially problematic in basements, where ground water and cooler temperatures encourage water vapour to collect. The appearance of mould indicates a serious condition – take immediate action. Lowering temperature and relative humidity levels and increasing air circulation are usually required to discourage future mould growth (Read, 1994).

An interesting and innovative way of approaching fungal deterioration is the study on the anti fungal activity of homoeopathic drugs against fungi isolated from damaged books (Garg, 1995).

One way of preventing mould growth on books in the absence of air-conditioning is to paint the hard covers with shellac (containing an insecticide) and to cover the paper jackets with plastic. This was practised in the 1960s in Malaysia (personal communication Rita Warpeha, Smithsonian/National Academies of Science, March 31 2001) but if this is still practised today is to be questioned

7.3.2 Insects

Insects are dangerous to archive material and are a potential threat, particularly in tropical countries. In temperate regions, although the problem exists, it is not as serious (Kathpalia, 1973).

Silverfish, firebrats, psocids (also called booklice), and cockroaches are among the most common library pests. Silverfish and firebrats can reach up to 12.5 mm in length; they feed on paper size, chew holes in paper (especially glossy paper), and damage bookbindings and wallpaper to get to the adhesives underneath. They also feed on textiles, primarily rayon, cotton, and linen. They prefer dark, humid areas that are undisturbed for long periods of time. Psocids feed on microscopic mould growing on paper, and thus their presence usually indicates a humidity problem in the storage area. They are much smaller than silverfish and firebrats, about 1-2 mm, and may also feed on pastes and glues, but they do not produce holes in paper. Cockroaches are omnivorous, but are especially fond of starchy materials and protein; they will eat book pages, bindings, adhesives, leather, and wallpaper. Cockroaches will chew holes in paper and bindings, but can badly stain materials with their secretions as well. Cockroaches are thigmotactic, meaning that they like to be in contact with a surface on all sides of the body; they seek very small crevices, between framed objects and the wall, etc. (Lindblom Patkus, 1999).

7.3.2.1 Silverfish and firebrats

Silverfish and firebrats are among the most ancient of insects. They were present on earth before insects developed wings. These pests were among the most common insects in homes and businesses when wallpaper was the usual wall covering and when coal furnaces had glued, taped and insulated pipes.

The silverfish and the firebrat are the most common representatives of the bristletails. Pest bristletails are about 1/2 inch long when adult and, unlike other insects, they continue to moult and may shed their exoskeletons as many as 50 or 60 times when full-grown. They have long antennae in the front and three antenna-like protrusions on the abdomen (the bristles of the bristletails). They are slender, broadest in front and gradually tapering toward the rear. In general, they shun light and prefer dark, undisturbed sites. The scientific name for the common silverfish is Lepisma saccharina.

Firebrats are not silvery but mottled dark grey and dull yellow. Their distribution, size, shape and appendages are like those of silverfish, but firebrats prefer decidedly higher temperatures and surroundings that are 90˚F or more. Examples of firebrat habitat are bakeries, where heat and starches are prevalent; furnace rooms; steam pipe tunnels; hot apartment bathrooms; and partition walls of water heater rooms.

7.3.2.2 Cockroaches

Cockroaches have survived for more than 300 million years. Ancient cockroach fossils have the same appearance as today's cockroaches: oval and flat with long legs and antennae. The modern cockroach has the same need for a warm, moist climate. Worldwide there are 3,500 kinds of cockroaches. Though most live wild in the tropics, a few, called urban cockroaches, prefer the even temperature and moist conditions that humans maintain in their homes and workplaces. Knowing similarities among and differences between species is important. Communicating this knowledge will give clients more confidence in the professional ability of their pest controllers. By considering the habits, the applicator can consider effective measures to control cockroaches. Except for size, all cockroaches are relatively similar in overall shape and appearance. They are nocturnal and stay in the dark whenever possible. When they are seen in the open or in the light, it usually means that a large infestation is present. Cockroaches also like tight hiding places where their bodies can touch surfaces both above and below. As they grow to adulthood, they will seek varied living spaces to accommodate their increasing size. Cockroaches are particular about where they live – they do not uniformly infest one room or all rooms. The three most common cosmopolitan cockroaches are the German cockroach (*Blatella germanica*), American cockroach (*Periplaneta americana*), and the Oriental cockroach (*Blatta orientalis*).

7.3.2.3 Termites

Termites belong to the insect order *Isoptera*. In nature, termites are considered beneficial because they break down dead and dying plant material. It is when termites feed on wooden structures that they become pests. Three types of termites occur: damp, dry wood and subterranean termites. Subterranean termites nest in the soil from which they obtain their moisture. They may attack any wood in contact with the soil. If there is no direct wood to soil contact, the termites may build mud tubes or tunnels within the cracks of foundations or over the outside of concrete to reach wood several feet above the ground. To a limited extent, termites are capable of regulating temperature conditions in the colony. Their galleries often are situated so that some run above ground and some below. Therefore, during extremes of hot and cold weather, the termites will be found below the ground where the conditions are more equitable. Subterranean termites need a constant, ample supply of moisture. Part of this moisture is procured from the products of their own metabolism and part from soil moisture, which diffuses throughout their tunnels or tubes. Since the subterranean termite colony usually obtains its moisture from the soil, they are generally dependent on soil types. Moisture in clay soils is tightly bound to the particles and not readily available to the termite. Sandy soils allow more moisture to be available and, consequently, these termites are more prevalent and able to survive in sandy soils. Fungi, when present in the wood, will serve as another source of moisture. These fungi aid in the regulation of humidity in the galleries. The plugs of partially chewed food and faeces placed by the termites in the passages also assist in moisture regulation. Occasionally, subterranean termites can be found above ground, isolated from the soil. This can occur if moisture is available from a source other than the soil. Common sources include condensation, and leaking pipes and roofs. Wood is made up primarily of cellulose, a large complex chain of relatively simple chemical molecules. Few animals have the necessary body chemistry to break down cellulose into smaller, more usable nutrients. Termites accomplish this by the presence of protozoa in their hindgut rectum. These protozoa break down the cellulose into products that the termites can digest. If these protozoa are removed, the termites will eventually die of starvation.

7.3.3 Rodents

7.3.3.1 Rats

Rats, in particular have caused more human suffering and more economic damage than any other vertebrate pest, from causing plague epidemics, the Black Death of Europe, to rat-bite fever. Statisticians estimate that rats destroy 20 percent of the world's food supply every year, directly by feeding and indirectly through contamination. Rats gnaw constantly and their teeth are extremely hard. They commonly chew through building materials such as cinder block, aluminium siding, sun-dried adobe brick, wallboard, wooden cabinets, lead sheathing, and plastic or lead pipes. After gnawing a hole, an adult rat can compress its body and squeeze through an opening only 0.5 inch high. In most instances, rats are very wary. Their control requires an integrated approach that includes non-lethal tools such as careful inspection, upgraded sanitation, and rat-proofing structures. Lethal control often combines the use of rodenticides, any substance that is used to kill rodents, with non-toxic control measures such as snap traps or glue boards. Within a population, some rats will be easy to control, some difficult. Successful long-term rat control is not simple. The key is to control rat populations, not individual rats (Strong, 1987).

Rats have adapted to most human environments. They are marvellous athletes and successful survivors as well. Successful long-term rat control is not simple. To control the rat they must be understood. Two of the most important biological factors to help control rats are their fear of new objects and their large foraging range of 100 to 150 feet or more from their nest. Successful rat control programs usually use a combination of tools and procedures to knock down a rat population and keep it down. In the long term, the most successful form of rat control is to build them out, also called rat proofing. Other control tactics include trapping and poisons. When using rodenticide baits and tracking powders, care must be taken to avoid risks to people, children, pets, and non-target animals.

The most common rat is the Norway rat (*Rattus norvegicus*), which is also called brown rat, house rat, sewer rat, and wharf rat. The Norway rat is generally considered the most important rat in the world. It is found in every country. Another widespread species is the roof rat (*Rattus rattus*), also called black rat.

7.3.3.2 Mice

The house mouse is the most successful rodent in adapting to live with people. It is found almost anywhere people are, feeding on human food, sheltering in human structures, and reproducing at a remarkable rate. It is the most troublesome and economically important vertebrate pest, contaminating untold millions of dollars worth of food, damaging possessions, and causing electrical fires with its constant gnawing. Many control failures against house mice are due to the applicator's lack ofunderstanding of mouse biology and habits, particularly the major differences between mice and rats. Mice have a remarkable reproductive ability. A mated pair can produce 50 offspring in one year. They also have a foraging range much smaller than a rat's, usually only 10 to 30 feet. Baits, traps, glue boards, and the like must be placed close to the nest to be effective. Thus, good inspections are critical. On the plus side, mice are curious and investigate new objects in their territory, so control measures can work fast when done correctly. Control of house mice is best when it is a three-part process: sanitation, mouse proofing, and population reduction with traps and toxicants. The scientific name for the common house mouse is *Mus musculus*.

7.3.4 Other Small Pest Animals

Although rats, mice, and birds are the vertebrate pests most commonly encountered in the urban environment, other vertebrates sometimes become pests, too. Some of these animals become pests when they wander into residential areas from nearby wild areas or parks.

7.3.4.1 Birds

Birds provide enjoyment and recreation while greatly enhancing the quality of life. These colourful components of natural ecosystems are studied, viewed, photographed, enjoyed, or hunted. Bird watching as a sport and recreational activity involves more than 10 million people. For this reason, birds are strongly protected by laws, regulations, and public opinion. Birds can become pests, however, when they feed on crops, create health hazards, roost in large numbers on buildings, contaminate food, or create a nuisance. No particular species can be flatly categorised as good or bad. Whether birds are beneficial or harmful depends on time, location, and activity.

In particular the common pigeon can be a real nuisance for the archives. The domestic pigeon (*Columba livia*) developed from the rock doves of Europe and Asia and was introduced into the United States as a domestic bird. Rock doves originally nested in caves and holes, and under overhanging rocks on cliffs, so they adapted comfortably to window ledges, roofs, eaves, steeples, and other components of man-made structures. Pigeons give pleasure to many people. Along with house sparrows, they may be the only friendly wildlife observed by many people living in an inner city. Many park visitors have adopted special pigeons that they feed every day. Pigeons are also bred for racing, stunt flying, and meat production. Pigeon racing is a sport in Europe and in some parts of the world, with birds racing distances of 10 to 1,000 miles (the record is 3,000 miles). Pigeons are used for scientific research on heart disease in humans and diseases of domestic chickens. They are raised for food. The meat of pigeons, referred to as squab, is considered a delicacy. Pigeons have become the most serious bird pests associated with buildings.

7.3.4.2 Bats

Bats are unique in the animal kingdom – they are the only true flying mammals. A thin membrane of skin stretches from the long, modified front legs to the back legs and then to the tail. The bones in the bat's 'fingers' are greatly elongated and support the wings. Bats are almost always beneficial. Many bats feed on insects and can consume up to half their body weight in insects in one feeding. Occasionally, however, they become a nuisance inside buildings or pose a public health problem. Roosting and hibernating sites may occur in building attics, wall and ceiling voids, belfries, chimneys, unused furnaces, and the like. The bats' droppings and urine can cause a foul odour and stains in walls and ceilings. Their squeaking and scrambling noises can be intolerable to residents of the building. Bats are associated with a few diseases that affect people.

7.3.4.3 Snakes

Most snakes are non-poisonous, harmless, and beneficial. But few people want them in their homes. In general, poisonous snakes have a large triangular head, a pit between the eye and nostril, and vertical and elliptical pupils. They may also have rattles on their tail, noticeable fangs, and a single row of scales between the vent (anal opening) and the tip of the tail. When uncertain assume that the snake may be poisonous and take appropriate precautions. Snakes are predators. Depending on the species, their diet may include insects, rodents, frogs, birds, worms, or toads. Some snakes hibernate in dens during the winter, wet, or dry season, sometimes under houses. At certain times of the year, they may enter buildings for warmth, shade, or moisture, or in search of prey. When managing a snake problem, keep in mind that the snake may be a protected species.

7.3.5 Literature

There is a lot of literature on particular pest groups. In the Rentokil Library several good books on a few of these pest groups have been published (see Rentokil website).

For some literature on silverfish, etc see *Iftikhar et al.,1984; Kalshoven, 1938; Kraemer Koelier, 1960; Lehmann, 1965; Mori, 1975; Olkowski et al., 1987; Pöschko et al., 1997; Shipley, 1925; Sweetman, 1938.*

For some literature on cockroaches see *Cornwell, 1968 and 1976; Olkowski et al., 1984; Robinow, 1956; Schal et al.,1990; Urs, 1993.*

For some literature on termites and other wood-boring insects see *Anonymous, 1944b and 1950; Becker, 1977; Chand, 1976; Ebeling et al., 1965; Fuxa, 1987; Gay, 1963; Grassé, 1966; Hadlington, 1987; Harrington et al., 1993; Harris, 1943 and 1962; Hickin, 1971a; Jahan et al., 1995; MacGregor, 1950; Mori, 1984; Mossberg, 1990; National Archives of India, 1991b; Noirot et al., 1947; UNESCO, 1960; Rauch, 1984; St. George et al., 1960; Velderrain, 1991; White, 1970; Williams, 1973; Williams, 1977.*

For an overview of timber infestation and preservation of the first 50 years of the 20th century see *Grenou et al., 1951.* For more literature on preservation and pest control of wood and timber see *Becker, 1977; Benoit, 1954a and 1954b; Bravery, 1977; Bultman et al.,1987; Building Research Establishment, 1980; Coleman, 1978; Findlay, 1985; Fortin et al., 1976; Gowers, 1970; Hickin, 1978; Mori, 1984; Ocloo et al., 1980; Paton et al., 1987; Tack, 1980; Unger et al., 1993; Werner, 1968; White, 1970; Wilkinson, 1979; Williams, 1973.*

For some literature on rodents see *Jackson et al., 1997; Meyer, 1998; Olkowski, et al., 1986 and 1991; Rauch, 1984; Strong, 1987.*

Although published some time ago Mary Wood Lee's UNESCO publication on mould is still worthwhile reading *(Wood Lee, 1989).* For more on mould see *Aberg, 1989; Anonymous, 1950; Ezennia, 1993; Heim et al., 1968; Hoffman, 1963; Keller, 1959; Lim et al., 1989; National Park Service, 1993; Plumbe, 1961a; Rytkonen et al., 1988; Scott, 1994 and 1996; Upsher et al., 1972; Wee et al., 1980.*

7.4 Treatments

The number of pests is enormous, there are many thousands of possible local pests to deal with which makes it difficult to fight them, as there is no single solution. It is important to remember that sighting one or two insects is an occasion for monitoring to determine the extent of the problem; it is not necessarily a crisis situation. In the past, insect sightings often occasioned an indiscriminate use of pesticides. If a serious insect infestation occurs, or if insect problems do not respond to the preventive techniques discussed above, direct treatment for insect infestation may be necessary. This strategy should be used as a last resort. Both chemical and non-chemical treatments are available; non-chemical means should be used wherever possible.

Library and archival collections can be threatened by a variety of pests that damage paper-based and other materials. The method of pest control least damaging to collections and staff involves preventive measures and regular monitoring. If infestation does occur, treatment should be tailored to the specific insect species and the type of material that is infested. Chemical treatments should be avoided except as a last resort. Emerging technologies such as blast freezing and modified atmospheres have significant potential as alternatives to chemical control (NEDCC website).

Reports of research and experience with pest control have appeared frequently in the conservation literature of the last years. When fumigation is necessary to control insects, freezing is the current method of choice. Inert gases are seen as promising fumigants, though few institutions have facilities yet for using them. Inert atmospheres can be provided within enclosures by exhausting the air and pumping in carbon dioxide, nitrogen or argon. A fumigation bubble adapted for this purpose has appeared on the market in recent months, and is still under development. It speeds the fumigation process by use of controlled heat (McCrady, 1992).

Libraries and archives have traditionally relied on pesticides for routine pest prevention and response to observed infestation. Pesticides often do not prevent re-infestation, however, and application of pesticides after the fact cannot correct the damage already done. Pesticides have also become less attractive because of a growing awareness that the chemicals in pesticides can pose health hazards to staff and damage paper-based collections. Newer extermination methods such as controlled freezing and oxygen deprivation have shown promise as alternatives for treatment of existing infestations, but like pesticides, they do not prevent re-infestation. Prevention can be achieved only through strict housekeeping and monitoring procedures (Lindblom Patkus, 1999).

7.4.1 Fumigants

In the past, fumigation was seen as the sole means of ensuring elimination of pest infestations. Often facilities were fumigated on a regular basis, even when there was no immediate threat (Ling, 1998).

The premises of a repository should be completely independent of one another. The rooms should be spacious, with plenty ventilation. But they should not be more than 200 m^3 in volume, so that they can be disinfected separately if necessary (Davison, 1981).

The use of fumigants involves exposing infected material to a lethal gas. Fumigants are among the most toxic of pesticides. Fumigant gases remain in the air and can easily spread over a wide area.

In general, fumigants and other pesticides can cause long- and short-term health problems, ranging from nausea and headaches to respiratory problems or cancer. Many chemical treatments may cause no ill effects at the time of exposure, but may be absorbed into the body to cause health problems years later. Many of the chemicals also damage the treated materials and no chemical treatments provide a residual effect that will prevent re-infestation. Growing awareness of the risks has brought about increased emphasis on non-chemical pest-control methods.

7.4.1.1 Ethylene Oxide

Ethylene oxide (ETO), a gaseous fumigant, was commonly used in libraries and archives until the 1980s; many libraries had their own ETO chambers. ETO is effective against insect adults, larvae, and eggs. It poses serious health hazards to workers, and there is evidence that ETO can change the physical and chemical properties of paper, parchment, and leather. Governments have steadily lowered acceptable limits on ETO exposure, and most existing ETO chambers in libraries cannot meet these restrictions. Some residual ETO remains in treated materials, and little is known about the long-term risks to collections and staff from off-gassing toxins. ETO should be used only as a last resort; materials should be sent to a commercial facility and allowed to off-gas for several weeks at least before being returned to the library or archives. In the Netherlands ETO is forbidden as a treatment for paper and related products.

7.4.1.2. Methyl Bromide

Sometimes methyl bromide is used instead of ethylene oxide. Methyl bromide is sold under different names: Brom-o-Gas, Celfume, Embafume, MB, MeBr, Methogas, Profume, Terr-o-Gas, and Zytox. It is a colourless, volatile liquid or gas with a chloroform-like odour. When used as a soil fumigant, only a small amount of methyl bromide is transformed into the bromide ion while much of the gas enters the atmosphere. Methyl bromide is moderately toxic to aquatic organisms. In the Netherlands methyl bromide is banned as a soil disinfectant in greenhouses. In its place hot steam is applied which is much better for the environment.

Even a little methyl bromide is highly toxic. Studies in humans indicate that the lung may be most severely injured by the acute (short-term) inhalation of methyl bromide. Acute inhalation of methyl bromide frequently leads to neurological effects in humans. Effects may be delayed.

Data suggest that mild functional neurological impairment may result in humans chronically (long-term) exposed to methyl bromide by inhalation exposure.

7.4.1.3. Sulphuryl Fluoride

Vikane is the commercial name for the gas sulphuryl fluoride. The gas is in use to fumigate wood and timber structures. It penetrates deeply into the woods and often thoroughly eliminates the pests. Depending on the construction of the building, the doors and windows may be sealed with tape and a plastic sheet, or the structure may be covered with a tarpoline. The building will remain sealed for 2-72 hours depending on the specifics of the job. Warning signs should be posted around the building, notifying people to keep out. After the tape is removed, a professional fumigator will aerate the structure by opening the doors and windows. Fans may also be used to clear out the building. Once the edifice has been thoroughly aerated, the fumigator is required to measure the level of any fumigant remaining in the living space to ensure it is below the approved concentration for re-entry by the occupants. The fumigator will post a notice on the building indicating the day and time for re-entry. Because Vikane is a true gas and not a vapour, aeration is rapid. Recent studies demonstrated that in most structures levels are less than 1 part per million within 6 hours of clearing and have no detectable levels of Vikane within 24 hours after the start of aeration.

Research has been undertaken to assess the potential damage of Vikane to modern and traditional resins and waxes pigments, as well as metals. The scientists investigated the potential interaction between Vikane and proteins and dyes. Little to no visible damage to materials was noted when Vikane was properly applied. The results indicate that some possible harm could be inflicted to archival materials Additionally, it was determined that documentation of fumigation should be recorded for each object so that future treatments take the fumigation history into account.

Sulphuryl fluoride (Vikane) is a colourless and odourless gas. It is therefore imperative to add a warning agent to this gas. Sulphuryl fluoride is a potential health hazard and enters the body through inhalation. Overexposure to high levels of sulphuryl fluoride can result in nose and throat irritation and nausea. At high concentrations (such as those used during fumigation) it can cause excess fluid in the lungs, sleepiness, pneumonia, and convulsions. These symptoms would be expected to appear within 8 hours after such an exposure. In the unlikely event that staff experience these symptoms in the building that has been recently fumigated, they should leave immediately. The pest control company should retest the building. Because sulphuryl fluoride is a gas, it does not stay on dry surfaces, thus there is no exposure when touching treated surfaces.

7.4.2 Non-chemical Treatments

A variety of non-chemical processes for exterminating insects have been explored. The most promising are controlled freezing and the use of modified atmospheres. Methods that have not proved as successful include the use of heat, gamma radiation, and microwaves.

7.4.2.1. Freezing, Freeze-drying And Other Cold Treatments

Controlled freezing has been applied in various institutions over the past 15 years. Reports on its effectiveness have been largely favourable. Freezing is attractive because it involves no chemicals and thus poses no hazard to library staff and the environment. It can be used on most library materials and does not appear to damage collections, but research into this question is not yet complete. Very fragile objects, those made from a combination of materials, and artefacts with friable media should probably not be frozen. Materials can be treated in household or commercial freezers, blast freezers, or controlled-temperature and humidity freezers. It is necessary to bag and seal items unless a freezer with specially controlled temperature and humidity is used. Bags must be sealed immediately to prevent insects from escaping. Some institutions box materials and then bag them. Bagging protects objects from changes in moisture content during defrost cycles and from condensation on cold books when they are removed from the freezer. It is essential to guard against freeze resistance; some insects can acclimate to cold temperatures if they are kept in a cool area before freezing or if freezing happens too slowly. Research is incomplete in this area; it is not known if common library pests are able to develop freeze resistance. In the absence of definitive data, material must be kept at room temperature until freezing begins. Items should not be packed too tightly within a freezer, since this can slow the freezing process. Most important, material should be frozen quickly. Freezer temperature should reach

0˚C within 4 hours and –20˚C within 8 hours. The most commonly reported successful treatments have been carried out at –29˚C for a period of 72 hours. It is unknown whether lower temperatures for a shorter time would be equally effective; there are reports that –20˚C for 48 hours has also been used with success. Collections should be slowly thawed (brought up to 0˚C over 8 hours) and brought up to room temperature. The entire process should then be repeated to insure effectiveness. Objects should remain bagged (some institutions leave them bagged for 6-8 months) until monitoring in the space indicates that the insect problem has been solved. Detailed documentation of each phase of treatment should be maintained. Like chemical treatments, freezing provides no residual benefits. If collections are not returned to a well-maintained storage area, re infestation will almost certainly occur.

Insect pests in museums may be eradicated by freezing as an alternative to the use of fumigants and pesticides. To avoid damage from the freezing process, specimens (herbarium specimens, dried skins, taxidermy specimens, mounted insects, skeletons, etc.) must be sealed in polyethylene bags at room temperature, cooled steadily to –20 ˚C, and held at this temperature for at least 48 hours. The bag must not be opened until the contents have thawed to room temperature (at least 24 hours). Repeated freeze-thaw cycles are recommended to assure insect eradication. Freezing to control insect pests in museum specimens will be most effective when it is used as a component of an integrated pest management program. (Florian, 1990)

7.4.2.2 Heating

Heat can effectively exterminate insects; it has been used widely used in food processing and in the production of medicine. A temperature of 140 ˚F for at least one hour will kill most insects. Heat should not be used to eliminate insects from paper collections, however, because heat of this magnitude greatly accelerates oxidation and paper ageing. At these temperatures paper will become brittle.

7.4.2.2.1 Thermo Lignum-system

The Thermo Lignum® process eradicates insect pests with warm air and without any chemicals. It is swift and sympathetic to health and environment. Objects of any kind are treated under optimum conditions by means of a complex, electronically controlled chamber system. Object moisture readings are taken and provide the starting parameter for the process. Based on this data all other relevant process factors are calculated and programmed. A thermal processor unit controls the complete procedure whilst the key parameters in the chamber: temperature, relative humidity, and object core temperature are logged and displayed by computer.

There is no doubt the system works in killing insects, and may be efficacious in killing some moulds. The conservator's fear is the application of high temperatures. The perceived worries are the effect of high temperatures (above 50˚C) causing the following problems: softening of waxes, synthetic adhesives, surface coatings, etc. Other problems are materials with low glass transition temperatures; direct expansion of brittle materials such as glass; shrinkage of animal skins in leather-bound books (Child, 1994).

7.4.2.3 Modified Atmospheres With Low-oxygen Or Inert Gases

Modified atmospheres have been used widely in the agricultural and food industries to control insect infestation. The term refers to several processes: decreased oxygen, increased carbon dioxide, and the use of inert gases, primarily nitrogen. Cultural institutions over the past 10 years, have undertaken various experiments with modified atmospheres with generally successful results. Modified atmospheres show great promise, but additional research is needed to determine optimum exposure times and methods for particular types of insects. There appears to be no obvious damage to collections, but little research has been done on long-term effects. There is potential danger to staff from exposure to high levels of carbon dioxide, if that is used, but there are no residual effects on collections. Modified atmospheres can be applied 1) in a traditional fumigation chamber or a portable fumigation bubble or 2) in low -permeability plastic bags. With a chamber or a bubble, materials are prepared for treatment (quarantined, documented, and loaded into the treatment chamber), air is evacuated from the chamber, and carbon dioxide (generally about 60% concentration) or nitrogen (to achieve an atmosphere of less than 1% oxygen) is introduced. Once the desired atmospheric concentration is reached, conditions are maintained at a specific temperature and relative humidity for the required amount of time. Once treatment is finished, the vacuum is released, the carbon dioxide or nitrogen is removed, the chamber is aerated, and materials are removed to a quarantine area so that the effectiveness of treatment can be assessed. The process for treating materials in low-permeability plastic bags is similar, except that materials are sealed in bags with an oxygen scavenger that will reduce the oxygen level in the enclosure to less than what is needed for insect respiration. In some cases, the bags are purged with nitrogen before sealing. In the tests conducted thus far, a variety of exposure times, temperatures, and relative humidities have been used. Since requirements for achieving an acceptable kill rate seem to vary according to the type of insect being exterminated and the type of process being used, there are not yet any generally accepted guidelines for the application of modified atmospheres. Always contact a preservation professional for advice before proceeding with modified atmosphere treatment.

7.4.2.4 Gamma Radiation

Gamma radiation is used to sterilise cosmetics, food and agricultural products, medical supplies, and hospital and lab equipment. It poses some danger to personnel during treatment, but there is no residual radiation in the treated material. Gamma radiation can be effective against insects, but the minimum lethal dose for various species is still unknown and is affected by variables such as climate conditions and the nature of the infested material. Most important, research has shown that gamma radiation may initiate oxidation and cause scission of cellulose molecules; it has the potential to seriously damage paper-based materials. There is also a cumulative effect from repeated exposures. As a result, gamma radiation is not recommended. In the Netherlands there is no other option to treat archive in bulk.

7.4.2.5 Microwaves

Rumours about the effectiveness of microwaves for killing insects have circulated in the library and archive community over the past several years. Microwaves are used successfully in the food, agricultural, and textile industries to control insects, but this strategy is not recommended for library and certainly not for archival collections. Microwaves have a limited penetration, and may not penetrate thick books. Their effectiveness also depends on the type of insect and the intensity and frequency of the radiation. Microwave ovens vary in intensity, so it is extremely difficult to determine standard times and temperatures for treatment. The primary argument against microwaves is the danger of damage to treated materials. Evidence from a variety of experiments indicates that pages and covers can scorch; metal attachments like staples can cause arcing; and adhesives can soften, causing pages to detach from their bindings in certain books. When metallic objects (staples, paperclips, spiral binders, etc.) are indiscriminately placed in a microwave oven cavity, the energy pattern becomes disrupted and distorted. This condition produces arcing. Two metal objects, such as a staple and the metal cavity wall, are placed in close proximity and subjected to an intense field of microwave energy, arcing will result. Arcing occurs because the air between the two metallic objects becomes electrically charged, just as the air between a thundercloud and the earth becomes charged or ionised. This ionised air becomes an electrical conductor, and electric current then leaps the gap like a small bolt of lightning. However, lightning only lasts for an instant because it discharges or neutralises the ionised air, but an arc in a microwave oven will continue, to a greater or lesser degree, as long as the microwave energy is applied. At the very least, this can cause marking or pitting of involved surfaces, and at worst, can burn a hole right through the cavity wall or object.

7.4.3 Traditional Methods

Man's battle against insect pests is not a battle of today. He has been fighting on this front since the dawn of history. We know from Homeric writings that the Greeks used sulphurdioxide to poison various insect pests. Gnadinger in his excellent book *Pyrethrum Flower* states that pyrethrum flowers were used as pesticides in Persia. In India aromatic plants and their leaves were used as insect repellents since ancient times. Those known to them were Gorbach or Shadgranth (*Acorus Calamus Linn*), Ashvagandha or Asana (*Withania Somnifera Dun*), tobacco leaves etc. (Swarnakamal, 1975). As early as the 5th century A.D. the Chinese papermakers added an insecticide to paper, manufactured from the seeds of the Amur cork tree. Later they were even obliged by law to add an insecticide to paper (Plumbe, 1987c).

In the 1950s and the 1960s a common, outdated, practice to protect books against insects was to varnish the book covers. The use of highly calendared board will also reduce infestation. Other precautions are the use of impregnated book cloth, nylon sewing thread, polyvinyl acetate adhesive (PVA) and no paper sizing with starch, dextrin, casein (Plumbe, 1987c).

Termites thrive in tropical and subtropical climates. It is worth recalling that termites have two deadly enemies, sunlight and fresh air (Duchein, 1988). An old and well-tried remedy against termites is avoiding contact of storage racks with the floor by keeping their legs in bowls containing creosote oil in kerosene oil (1 : 2) (Kathpalia, 1973; Talwar, 1993).

Gorbach is well known as an effective insect repellent and in the Konkan districts of Maharashtra it is known as *Pandri*. It contains an aromatic volatile oil and a bitter substance known as *lacorin*. Together they constitute a powerful pesticide. An attack by white ants is often checked by use of powdered Gorbach. Gorbach is an erect aromatic marsh herb, root-stock being thick and creeping. The leaves and the root-stock make a very effective insecticide. *Ashvagandha*, an erect branching under-shrub 1-5 ft. high, is another plant with similar properties. It was common practice to keep Gorbach and Ashavagandha in ancient repositories and libraries to protect books and manuscripts from damage by insect pests. Compounds of lead and arsenic have also been used to preserve valuable records. The exudation of the Indian Frankincense tree known as *Gugal* or *Dhup* is used in many parts of India and burnt as incense. It disinfects the house and serves as a fumigant to drive out insect pests. In some Indian museums leaves of certain aromatic plants, e.g. tobacco, *Neem* etc. are placed in show cases for the purpose of repelling insect pests (Swarnakamal, 1975).

7.4.3.1 Neem and Tea Tree

Today many repellents appear that are made of plant extracts. However, current advice is to be very careful with these traditional repellents. They are still poisonous and may be harmful to humans and the archival material. Plant products may seem environment-friendly but that does reduce poisonous characteristics. Conservators do well to remember that nature gives life as well as takes life. Some of these repellents are manufactured as insecticide papers that come in direct contact with the archives. Other repellents are oils smeared on or impregnated into the papers. Currently conservation scientists feel that two plant repellents are promising: extracts of the neem tree (*Azadirachta indica*) and tea tree oil (*Melaleuca alternifolia*). The tea tree is however poisonous because of the high contents of volatile carbonic compounds (turpentine).

In Australia, the oil of the tea tree (*Melaleuca alternifolia*) has been a time-honoured folk remedy for man and beast. At Macquarie University the anti-microbial activity of a large number of commercial tea tree oils was examined. Results demonstrated the importance of terpinen-4-ol for activity against microbes. The powerful anti-microbial activity of p-cymene, a minor component of tea tree oil, was confirmed. Some micro-organisms are highly susceptible to a combination of terpinen-4-ol and p-cymene. Tea Tree's essential oils are very closely related to turpentine, which was itself an old-fashioned and multi-use farm remedy. Less than fifty years ago turpentine was used to cure whatever ailed people and pets. There were reports of turpentine poisoning. Most people today realise that turpentine is more toxic than beneficial, but as turpentine has fallen out of favour, the use of chemically related Melaleuca oil has grown tremendously. Several studies have been published in respectable journals that back up the folk remedy claims. For example, Tea tree oil has a proven effect against a wide variety of bacteria, fungi, and yeasts. One study looked at the effects of the oil on normal skin bacteria versus effects on disease causing bacteria.

It was found that the oil was much more likely to harm the bad bacteria, leaving the good ones alone. The compounds responsible for healing however are the same compounds that can cause side effects and it is reasonable to assume that even small amounts could be harmful. About the use of the tea tree oil it is said that 'A little tea tree oil is good. But more is not better!'. Another aspect of tea tree oil's nature is that it is attracted very strongly to other types of oils. This is called lipophilic, literally fat loving, in scientific terms. Since the skin is rich in oils, the essential chemicals of Melaleuca can quickly be absorbed by the skin and enter the bloodstream.

The neem tree (*Azadirachta indica*) has much potential for its healing possibilities and also for dealing with insects. Much information can be found on the internet and currently Cornell University is researching the oil for its uses in conservation.

7.4.4 Literature

The quantity of literature on the subject, or rather subjects, in this section is substantial. Only a small selection is listed below.

For literature on fumigants see *Bond, 1998; Coleman, 1978; Gerozisis et al., 1990; Gillies et al., 1992; Haenel, 1964; Hengemihle et al., 1995; Leesch et al., 1978; McComb, 1983; Monro, 1975; Mori et al., 1974; Pinniger, 1998; Reade Fong, 2001; Smith, 1984b; Talwar, 1975*. For more information on the fumigant Vikane see the websites of the GCI and Dow Agro Sciences.

For literature on non-chemical treatments such as heat treatment, freezing and radiation see *Baust, 1973; Brezner et al., 1989; Daniel et al., 1993; Elert et al., 1997; Flint et al., 1981b; Florian, 1986; Forbes et al., 1987; Kaplan et al., 1996; Ketcham, 1984; King, 1984; Lawson, 1988; Leclerc, 1989; McCall, 1986; Nesheim, 1984; Paton et al., 1987; Peacock, 1998 and 1999; Smith, 1984a and 1986; Tanimura et al., 1995; Teply et al., 1986; Tilton et al., 1982a and 1982b; Urban et al., 1986; Valentin et al., 1990; Wilkinson, 1980.*

For traditional repellents see *Davi, 1989; Nair, 1993a; Samidi et al., 1993*. For tea tree and neem tree check the website of The Rural Industries Research and Development Corporation (RIRDC), the Neem Foundation. For some literature on this subject see *Ad Hoc Panel of the Board on Science and Technology for International Development. National Research Council, n.d.; Casey Sclar, 1994; Gateby et al., 2001.*

PART TWO

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APPENDICES

Appendix 1 : Glossary of Abbreviations

ABHB	Annual Bibliography of the History of the Book and libraries
ABRACOR	Associação Brasileira de Conservadores-Restauradores de Bens Culturais
ADRC	Asian Disaster Reduction Centre
AIA	American Institute of Architects
AIC	American Institute of Conservation of Historic and Artistic Works
ANRI	Arsip Nasional di Republik Indonesia
APOYO	Asociación para la Conservación del Patrimonio Cultural de las Américas
ARA	Algemeen Rijksarchief (ARA), National Archives of the Netherlands
BC	Before Christ
BS	British Standard
CARDIN	Caribbean Disaster Information Network
CDERA	Caribbean Disaster Emergency Response Agency
CECOR	Centro de Conservação e Restauração de Bens Culturais Móveis (Brazil)
CEOS-DMSG	Committee on Earth Observation Satellites / Disaster Management Support Group
CIDA	Canadian International Development Agency
CLIR	Council on Library and Information Resources
CDNLAO	Conference of Directors of National Libraries in Asia and Oceania
COAPS	Center for Ocean and Atmospheric Prediction Studies
CONSAL	Congress of Southeast Asian Librarians
CoPAT	Council for the Prevention of Art Theft
COSTFORD	Centre of Science and Technology For Rural Development
CPBA	Projeto Conservação Preventiva em Bibliotecas e Arquivos (Brazil)
ECHO	European Community Humanitarian Office
ESA	Earth and Atmospheric Science
ETO	Ethylene oxide
FEMA	Federal Emergency Management Agency
FHRC	Flood Hazard Research Centre
FIAT	Fédération Internationale des Archives de Télévision
FIDA	International Archival Development Fund
GCI	Getty Conservation Institute
GSHAP	Global Seismic Hazard Assessment Program
HEPA	High-Efficiency Particulate Air (filter)
HRL	Hazards Research Lab
HVAC	Heating, Ventilating, and Air Conditioning
IAP	Indoor Air Pollution working group
IAPMA	International Association of Hand Papermakers and Paper Artists
ICA	International Council on Archives
ICBS	International Committee of the Blue Shield
ICSU	International Council of Scientific Unions
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
ICOMOS	International Council on Monuments and Sites
IDNDR	International Decade for Natural Disaster Reduction
IDP	International Dunhuang Project
IFLA	International Federation of Library Associations and Institutions
IFRC	International Federation of Red Cross and Red Crescent Societies
IFTA	International Federation of Television Archives
ILP	International Lithosphere Program
INTACH	Indian National Trust for Art and Cultural Heritage
IPI	Image Permanence Institute
IPM	Integrated Pest Management
ISDR	International Strategy for Disaster Reduction
ISO	International Standard Organisation
KB	Koninklijke Bibliotheek (KB), National Library of the Netherlands
KIT	Koninklijk Instituut voor de Tropen (KIT), Royal Tropical Institute
NAA	National Archives of Australia
NARA	National Archives and Record Administration (USA)
NASA	National Aeronautics and Space Administration
NAS	National Archives of Singapore
NCSD	National Councils for Sustainable Development
NDRD	Natural Disaster Reference Database
NEDCC	Northeast Document Conservation Center
NEIC	National Earthquake Information Centre
NGO	Non-governmental Organisation
NHC/TPC	National Hurricane Centre / Tropical Prediction Centre
NIFC	National Interagency Fire Center
NLA	National Library of Australia
NLD	The National Diet Library (Japan)

NLIC	National Landslide Information Center
NOAA	National Oceanic and Atmospheric Administration
NRLC	The National Research Laboratory for Conservation of Cultural Property
PAMBU	Pacific Manuscripts Bureau
PBB	Polybrominated Biphenyls
PCB	Polychlorinated Biphenyls
pH	Potential of hydrogen = degree of acidity/alkalinity (1–14)
PI	Preservation Index
RAMP	Records and Archives Management Programme
RH	Relative Humidity
SAM	Seattle Art Museum
SEACAP	Southeast Asian Consortium for Access and Preservation
SKAT	Swiss Centre for Development Cooperation in Technology and Management
SOLINET	Southeastern Library Network
T	Temperature
TCP	Tropical Cyclone Programme
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UPS	Uninterrupted Power Supply unit
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
USGS	United States Geological Survey
UV	Ultraviolet
WCED	World Commission on Environment and Development
WMO	World Meteorological Organization
WWW	World Weather Watch

Appendix 2 : Addresses of Contacts and Institutes
in alphabetical order

Al-Furqan Islamic Heritage Foundation
Eagle House, High Street
Wimbledon
London SW19 5EF, UK
Tel: +44 181 944 1233
Fax: +44 181 944 1633
www.al-furqan.com

American Institute for Conservation (AIC)
1717 Sweet NW, Suite 301
Washington DC 2006, USA
Tel: +1 202 452 9545
Fax: +1 202 452 9328
Email: InfoAic@aol.com
aic.stanford.edu

Art Loss Register (ARL)
www.artloss.com

Architectural Institute of Japan
26-20, Shiba 5-chome, Minato-ku,
Tokyo 108-8414, Japan
Tel: +81 3 3456 2051
Fax: +81 3 3456 2058
Email: info@aij.or.jp
www.aij.or.jp/aijhome.htm

Arquivo Nacional
c/o Adriana Cox Hollós
Rua Azeredo Coutinho, 77
Centro, 20230-170
Rio de Janeiro, RJ, Brazil
Tel: +55 21 3806 6140
Fax: +55 21 3806 6139
Email: ccd@arquivonacional.gov.br
www.arquivonacional.gov.br

Asian Disaster Reduction Centre (ADRC)
3F, IHD Centre Bldg.
1-5-1 Wakihama-kaigan-dori
Chuo-ku, Kobe City
Hyogo Prefecture 651-0073, Japan
Tel: +81 78 230 0346
Fax: +81 78 230 0347
Email: rep@adrc.or.jp
www.adrc.or.jp/top.asp

Asociación para la Conservación del Patrimonio cultural de las Américas (APOYO)
P.O.Box 76932
Washington, D.C. 20013, USA
Tel: +1 202 707/1026/5634
Fax: +1 202 707/1525
Email: ator@loc.gov
Email: asei@loc.gov
imaginario.org.ar/apoyo/home.htm

Associação Brazileira de Conservadores-Restauradores de Bens Culturais (ABRACOR)
Caixa Postal 6557 - CEP: 20030-970
Rio de Janeiro - RJ, Brazil
Tel: + 55 21 2262 2591
Email: abracor@abracor.com.br
www.abracor.com.br

Association of Moving Image Archivists (AMIA)
c/o National Centre for Film & Video Preservation
8949 Wiltshire Boulevard

Beverly Hills, CA 90211, USA
Tel: +1 310 550 1300
Email: amia@amianet.org
www.amianet.org

Bishop Museum
The State Museum of Natural and
Cultural History
1525 Bernice Street
Honolulu Hawai'i, 96817-0916, USA
Tel: +1 808 847 3511
Email: museum@bishopmuseum.org
www.bishopmuseum.org

British Columbia
Ministry of Water, Land and Air Protection Pollution Prevention and Remediation Branch
Box 9342 Stn , Prov. Govt.
Victoria, British Columbia V8W 9M1, Canada
Tel: 250-387-4441
www.elp.gov.bc.ca/epd/ipm/docs/envirowe/default.htm

Canadian Conservation Institute (CCI)
1030 Innes Road
Ottawa ON K1A 0M5, Canada
Tel: +1 613 998 3721
Fax: +1 613 998 4721
Email: cci-icc_services@pch.gc.ca
www.cci-icc.gc.ca

Caribbean Disaster Emergency Response Agency (CDERA)
The Garrison, St. Michael
Barbados
Tel: +1 246 436 9650
Tel: +1 246 436 9651
Fax: +1 246 437 7649
Email: cdera@caribsurf.com
www.cdera.org

Caribbean Disaster Information Network (CARDIN)
Science Library, University of the West Indies
Mrs. Beverley Lashely
Project Coordinator
P.O.Box 104
Mona, Kingston 7
Jamaica, West Indies
Tel: +1 876 970 1757
Fax: +1 876 970 1758
Email: cardin@uwimona.edu.jm
www.cardin/uwimona.edu.jm

Center for Ocean and Atmospheric Prediction Studies (COAPS)
Bibliography El Nino and flooding, a global resource
(Robert M.) Johnson building in Innovation Park, 2nd Floor
Tallahassee, FL., USA
www.coaps.fsu.edu/lib/elninobib/enso-floods

Centre of Science and Technology for Rural Development (COSTFORD)
Ayyanthole
Thrissur 680 003
Kerala, India
Tel: + 91 487 360788
Fax: + 91 487 641678
www.c-itizen.com/costford

Centro de Conservação e Restauração de Bens Culturais Móveis (CECOR)
Escola de Belas Artes/UFMG
31270-901 - Belo Horizonte - MG Brazil
Prof. Luiz A. C. Souza
Tel: +55 31 4995 378/5
Fax: +55 31 4995 375
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coremans.eba.ufmg.br

Commission on Preservation and Access (CLIR)
1755 Massachusetts Avenue
NW Suite 500
Washington DC 20036-2188, USA
Tel: +1 202 939 4750
Fax: +1 202 939 4765
Email: info@clir.org
clir.org

Committee on Earth Observation Satellites (CEOS)
Disaster Management Support Group (DMSG)
Email: Levin.Lauritson@noaa.gov
www.ceos.noaa.gov

Congress of Southeast Asian Librarians (CONSAL)
National Library Board (NLB)
1 Temasek Ave 06-00
Millenia Tower
Singapore 039192
Contact: Ms. Eunice Low
Tel: +65 332 3133
Email: eunicelow@nlb.gov.sg
www.nlb.gov.sg
www.consal.org.sg

Conservation Dist List
Electronic discussion forum
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