1. Introduction

Forest ecosystems are the arsenal that supplies food and medicines for those who are the poorest members of the global community. These are referred to as “forest dwellers”. However, the extent of those who depend on the products of the forest go well beyond these humble forest dwellers. In the modern context, the forest ecosystems contribute to the diets and the medicines of even urban populations. This being so the widespread destruction of tropical rainforest ecosystems and the consequent extinction of plant and animal species that is ongoing, brings forth consequences that are of mind-boggling proportions. Though tropical moist rainforests are estimated to cover just only 6% of the surface of the earth, they contain an estimated 50% of all species of plants and animal life. The abundant botanical resources of the rainforests have provided mankind, and even neanderthal man, with food and medicines over several millennia. Yet it is just only 1% of this vast resource that has been scientifically evaluated for medicinal potential. At the same time an estimated 2% of the global rain forest resources are irreparably damaged each year, a rate which seems likely to witness the destruction of a possible 20-25% of the present species of flora and fauna, in a decade from now.

Rain forest resources are the basis on which the traditional medical systems have thrived. Medical systems such as the old Arabian-Greek systems from which modern western medicine is derived, the Traditional Chinese Medicine (TCM), the Ayurvedic, Siddi, and Unani systems, all depend substantially on plants for their therapeutic armoury. Therefore the safeguarding of the resource which is so vital to global health becomes a major responsibility of mankind (Wijesekera, 1991).

2. Some Contributions of Rainforest Products to Global Health

The Ayurvedic system of Medicine is largely dependent on plants for its therapeutic requirements. From the earliest days of disciplined treatment of disease, the texts of Vagbita, Susruta, and Charaka have described methods for the treatment of disease which are dependent on the use of various plant preparations to combat a variety of ailments which had been identified as those from which mankind suffered. It was the same with the other oriental systems. The Chinese too had an extensive system, again largely based on plant derived prescriptions drawn initially from the forest flora. Early Chinese texts such as that of Li Shi Shen gave very accurate taxonomic descriptions of the medicinal plants used. The next phase was the systematic cultivation of the

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medicinal plants to meet the burgeoning demands. Forests surrounding the Himalayan mountain range was according to Hindu mythology the region which had an abundance of plants with medicinal properties. In recent times a Rumanian botanist Ovidiu Bojor devised a system for harvesting the medicinal plants from the forests surrounding the Himalayan region near Nepal, without disturbing the relative abundance. He called it “economic mapping” because he drew maps that depicted the relative abundance of each of the various species and with it a method for systematic harvesting (Wijesekera, 1991).

Over the years, chemistry came into the equation. Early organic chemists who studied plants used in medical prescriptions because of their displayed biological action were keen to isolate what they deemed to be the “active ingredient”, and determine its chemical structure. Early organic chemistry was to develop along these lines, and then was identified as Phytochemistry or Natural Product Chemistry (Wijesekera, 1981; Bojor, 1991).

The discovery of the anti-malarial Quinine was one of these early epic stories. Malaria was a scourge then in Europe as well. The Jesuit priests working in Peru came across a native remedy drawn from the forests that was an effective counter for the dreaded disease. It was the bark of the Cinchona tree which the extract was the effective remedy. They were instrumental in sending it to France, where French chemists purified it and isolated quinine. It was the first remedy for malaria and it set off a trail for the search for other cinchona species, which contained the chemical quinine the proven anti-malarial agent. This was then a methodology trail for the search for potent drug substances. The story of quinine did not end there and it took chemists a long time to find its structure and still longer to synthesise it (Wijesekera and Tchecknavorian, 1982). The synthetic methods were not economically available to manufacture the drug for clinical use, hence the drug is still obtained from the plant material, viz: from several members of the cinchona species which have for long years now been on a cultivation basis in several regions of the world. Another landmark story is the discovery of Reserpine (Moore et al., 1954).

Figure 1: Chemical structure of Quinine and Reserpine.
Western medicine had not at the time, that is up to the twentieth century, yet identified the condition now called “hypertension”, and this was seen as a form of insanity, until the Pakistani chemist in pre-partition India, Salimuzzaman Siddiqui noted that certain forms of insanity was cured by Ayurvedic Physicians. They used the roots of a forest plant (*Rauwolfia serpentina* – snake root). Siddiqui isolated from it the alkaloid Reserpine, and together with the Swiss chemist Emil Schlittler, at Ciba Geigy, gave the world a cure for hypertension. Once again a forest plant used for years by Ayurvedic physicians in India had yielded a cure for a disease not even identified at the time in the Eurocentric medical sphere. Synthetic derivatives based on the chemical structure of reserpine are available for therapeutic use although the drug is also obtained from African as well as Asian species of *Rauwolfia*.

The various Curare species have been used by several indigenous populations as arrow poisons since antiquity. These have yielded alkaloids that are now used for the treatment of diseases such as multiple sclerosis, Parkinson’s disease and neuromuscular conditions. There are several such epic examples. but a selection of a few others are noted below.

Recent research has brought to the ambit of modern medicine the drug Prostialin. It was isolated in 1984 from a Samoan plant and has displayed use in combatting AIDS. Currently the most promising agents in combatting AIDS are also plant-derived drugs Calonolides A and B derived from the Malaysian species of *Calophyllum*.

The many examples of modern drugs derived from plant sources are now documented. (Moore et al., 1954; Wijesekera and Tchecknavorian, 1982; Wijesekera, 1991). In modern times it could be stated that over 7,000 compounds used in western medicine are derived from constituents of plants that originally came from the tropical rain forests and a 1985 estimate of the retail value of them is of the order of 45 billion USD.

3. Some Special Research Initiatives

The work of Carl Djerassi exemplifies another dimension of what research on Forest products can bring to the world. Djerassi found that in Mexico a yam from the *Diascorea* species had yielded according to the work of R.E. Marker, steroidal compounds such as Dioscin and Diosgenin.

Djerassi used Diosgenin as a starting point to synthetically produce the rare medicines, Prednisone, and Cortisone as well as to finally produce the oral birth control pill, as a synthetic product within economic reach of the ordinary population. It was an example which blazed a trail now hotly followed to utilise products from forest plants as starting points to synthetically manufacture identified medicinal agents (Djerassi, 1985; Chandraratna, 2015; Wijesekera, 2015).

Often these intermediates obtained from the natural source can considerably reduce costs of production to make the synthetic production of such compounds cheaper.
4. Searching for Medicines from the Rain Forest

There could be several approaches in searching for new medicinal agents from the rain forest (Barclay, 1981; Farnsworth, 1988; Rastogi and Dhawan, 1991; Xiao, 1991; Schultes, 1994; Soejarto, 1996; Tulp and Bohlin, 2002; Heidet, 2003; Mongabay.com, 2003; Weathers, et.al., 2011; Wijesekera, 2016).

- The biodiversity based approach
- The NCI model
- Taxonomic selection
- The ethnobotanical approach
- The traditional healer recommendation
- Entomological Approach

Ever since the structure of Quinine was elucidated chemists have been pursuing the goal of attempting to synthesise analogues expecting to craft a molecule with similar activity. This has been a definite objective of chemists for many decades now. There have been many failures on the way, but the success stories have been spectacular. Plants have provided the major range of chemical structural types for synthetic drug development.

These are all now well documented and plants used in Ayurveda and plants used in TCM have provided invaluable major leads to synthetic chemists (Wijesekera, 1981; Wijesekera and Tchecknavorian, 1982; Rastogi and Dhawan, 1991; Xiao, 1991).
One recent unique instance is the crafting of the molecule Captopril designed in 1975 from a molecule found in the venom of the Brazilian viper, *Bothrops jaracusa*, again, a reptile from a rain forest source. The synthetic compound was the very first in a new class of orally administered bioactive drugs known as ACE inhibitors on account of the biochemical entity they block. This drug, developed by the Nobel Laureate Sir John Vance and the firm Squib, would reduce blood pressure to tolerable levels when administered as a pill, which represents an enormous advance in treatment. As a group *Bothrope*-derived ACE inhibitors represent one of the most effective drugs yet discovered as they improve the health and longevity of so many patients worldwide. A recent prediction is that there would be by 2025 1.5 billion victims of hypertension worldwide (Lancet 2005 Jan 16) (Johns, 2006; Wijesekera, 2015).

There are now several chemical variations of the original captopril, (see below), which are used to treat ailments such as congestion heart failute (CHF) and other coronary ailments. It is noteworthy to recall that all these products derive from a forest reptilian species and has given humankind life-saving health benefits.

![Chemical structures of Captopril, Enalapril, Enantiocaptopril and Succinyl proline.](image)

Reptilian venum is now been studied as a new source of drugs. Snake venums are complex mixtures of pharmacologically active polypeptides and proteins and are therefore veritable goldmines for drug leads. Captopril and other synthetic derivatives have all been possible from the research into the snake venoms.
4.1 The biodiversity approach

This has been the approach taken by indigenous peoples throughout the ages during which their health needs were firmly based on the plant resources of the rain forests. Harvesting of forests plants too appear to have had systematic approaches that were designed to enhance growth of the weaker species, and to prevent the dominant species from sending the weaker ones into extinction (Bojor, 1991). Thus the forest biodiversity had to a large extent been sustained. Equally the forest resources have been responsible for the health of the world’s population even from the days prior to that of recorded time.

In times of scientific research the chemical structures of metabolites isolated from forest plants that have served mankind over the ages, have also served as templates for the synthesis of new bioactive substances. Sometimes it has been the case that chemists have made synthetic analogues that have proved to be better and more effective than the original natural natural product.

A notable case is that of Artimisinine isolated from the Chinese plant Quinghasu or *Artimisia annua*. This was a known and effective antimalarial in the traditional medicine of China and once the chinese team led by Mme Tu had proved its efficacy they were able to synthesise the ether derivative that proved to be even more effective. Mme Tu was awarded the Nobel Prize for medicine in 2015 for the work on this which is now the gold standard as an antimalarial drug (Wijesekera, 2016).

![Figure 4: Artimisia annua.](image)

4.2 The NCI model

The NCI was the first to pioneer a global screening program with specific activity elements in focus. During the decades 1960-80 they were able to collect samples of plant material for screening from Africa, Asia, and Latin America. The NCI collected over 60,000 samples of plant material for screening utilising partners such as research institutes, universities and scientific colleagues (Barclay, 1981; Farnsworth, 1988; Soejarto, 1996; Tulp and Bohlin, 2002; Heidet, 2003; Wijesekera, 2016).

This massive programme which had its own methodology of plant procurement and selective screening was able to unearth several anti-cancer agents such as Taxol, now in clinical use for several types of breast and ovarian cancers. Likewise the NCI programme was able to find
Vincristine, and Vinblastine isolated from the Madagascar periwinkle, (*Catharanthus roseus*), Vinblastine, now chemically synthesised, is used in the treatment of childhood leukemias while vincristine finds use in combating Hodgkins disease.

![Catharanthus roseus and its chemical compounds.](image)

The NCI claims that 70% of the plants possessing constituents that are effective in cancer therapy are found in the rain forest. The program also found rain forest plants that were promising in the treatment of AIDS, and several other human ailments. Though the method is expensive the results are of immense benefit to mankind, and enhances the maxim that the preservation of the rainforests are of supreme importance.

Chemists have also been able to use the templates of Vincristine to synthesise other potent molecules for use in humans, yet the drug is obtained from large scale cultivations of the plant due to the prohibitive costs of synthetic manufacture.

4.3 Taxonomic selection

This is a commonly used technique by scientific researchers. It seeks to collect rainforest plants from taxonomic species that have already proven to contain known bioactive agents. For example when the Chinese team led by Mme Tu found the *Artimesia* species contained Artimisinine, and studies demanded larger quantities of the chemical they sought other species and found that *A. annua* had a large content of the sought after compound. Hence domestic cultivation of the species was initiated (Wijesekera, 2016).

4.4 Ethnobotanical approach

This method is the most logical and has been largely followed. In traditional medicine both Chinese and Ayurveda have specified the utility of a large variety of plants and the ancient texts describe them. Using these as indicators and the knowledge of rainforest plants a search for new drugs can be logically planned. A study of the ethnomedical data on plants is a valuable first step in any new drug development initiative.

4.5 The traditional healer recommendation

In Africa in particular as well as in remote parts of the world such as the Amazon region, there may not be recorded data on plant species and their bioactivity, comparable to the ancient text available in Asia the Arab region and China. In these regions the recommendations of the traditional
healers called in Africa *Guerriseurs* or in Latin America, *Shamans*, would be an invaluable guide. Many a drug has reached the modern therapeutic armory through the recommendation of primitive practitioners.

4.6 *Entomological approach*

A novel recent method is to choose plants by observing guiding indications of insects. Entomologists of the Smithsonian Tropical Research Institute in Panama have developed a method based on insect guidance. They observed that in the forest brightly coloured bugs were prone to sit on bioactive plants.

They noted that the insects that feed on these plants virtually advertise the fact that they contain bioactivity. Insects ingest the bioactivents from plants, which make them poisoness to their predators, giving them a form of self defence. The brightly coloured insects seem to advertise their toxicity but they also give a tip to mankind’s hunters for medicines.

4.7 *Essential oils as green pesticides*

Essential oils, the volatile constituents of many a wide range of plants which gave the world the basis of the now dominant fragrance industry, are now seen as the new green pesticides. These are deemed to take over from chemical pesticides which are proven harmful. The rain forests are the arsenal of many an undiscovered species. Essential oils are now seen as possessing a wide spectrum of activity against insect pests, and plant pathogenic fungi, ranging from insecticidal, antifeedant, repellent, oviposition deterrent, to growth regulatory, and antivector activities (Wilson, 2008).

5. **Concluding Observations**

Recognition of the crucial need to preserve the forest ecosystems would be the primary global requirement of today. They serve the needs of humanity today and will do so perhaps for ever in the manner it had done so far. Mainly the special needs are as follows: (Barclay, 1981; Farnsworth, 1988; Schultes, 1994; Soejarto, 1996; Tulp and Bohlin, 2002; Heidet, 2003; Mongabay.com, 2003; Wijesekera, 2016).

- As suitable and accessible medicines and foods for forest dwellers.
- As sources of new food items and medicaments for urban populations
- As raw material for processed foods and medicines for the general population.
- As sources for the isolation of singular metabolites and studies of the chemistry, of possible agents with new bioactivities to combat the emergent diseases..
- To serve as templates or models for synthetic drug manufacture.
- As sources of special food supplements eg. Vitamins, xanthophills, & polyphenols etc.

The destruction of the forest ecosystems can happen in several ways. Wilful destruction generally in the name of “development projects” is the commonest although under this will also come the hunt for timber. Destructive methods such as the “Chena” cultivation and such like modern versions are inclusive of the trend. The quest for timber and the menace of animal hunting for tusks as an example, contribute hugely to the pattern of destruction.
The famed Botanist, Richard Schultes has described these acts as “Burning a Library” Neglect of the forest system can also be significant when the more invasive plants overcome those that are less strong but are more useful in respect of their range and quality of potential metabolites they contain (Barclay, 1981; Djerassi, 1985; Farnsworth, 1988; Chandraratna, 2015; Wijesekera, 2015). This draws attention to the key role of forest management.

In recent times, the author has noted many such destructive examples in Asia, Africa and Latin America. These have all happened in the name of development. The cost would be beyond estimation for instance as in the case in little Sri Lanka, when the Randenigala Dam was constructed. Who can measure the cost of the biodiversity lost in that exercise? What may have been the alternatives that could have been less expensive in terms of biodiversity loss? Such are not often considered in the modern age blindness of destruction. The food requirements of an endangered world, and the often intractable nature of the new emerging disease patterns demand that for the sake of future generations the biodiversity onslaught by man has to cease for his own sake. The destruction of biodiversity encompasses all organisms, not only plants but animals, fungi and such-like which are equally of ultimate use to humankind. Island nations such as ours, Madagascar, Jamaica, the many islands of Indonesia, are very rich in biodiversity and the rain forests are indeed mankind’s future saving grace. Present populations do not even regard this as such and will have to pay a heavy price for this. Richard Schultes’s “destruction of a Library” (Djerassi, 1985) may mean so much more than that. In the words of the Secretary-General of the United Nations “there will be no second chance, No Plan B, quite simply because there is no Planet B.”

![Figure 6: The Author during a visit to a well managed Australian Rain Forest near Cairns.](image_url)
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