Critical study of *"Vṛkṣāyurveda"* texts for the cultivation of Medicinal and Aromatic Plants (MAP)

Thesis submitted to the University of Hyderabad
in partial fulfillment of the requirements
for the award of the degree

Doctor of Philosophy
in
Sanskrit Studies

By

C.G. Krishnamurthi,
14HSPH02

Department of Sanskrit studies,
School of Humanities,
University of Hyderabad
Hyderabad – 500 046, India

March 2021

DECLARATION

I hereby declare that the thesis entitled - Critical study of '*Vṛkṣāyurveda'* texts for the cultivation of Medicinal and Aromatic Plants (MAP)' submitted by me under the guidance and supervision of Prof. J.S.R. Prasad, Department of Sanskrit Studies, School of Humanities, University of Hyderabad, India is a bonafide research work which is also free from plagiarism. I also declare that it has not been submitted previously in part or full to this or any other University or institution for the award of any degree or diploma.

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Roll Number: 14HSPH02
Department of Sanskrit Studies,
School of Humanities
University of Hyderabad

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CERTIFICATE

This is to certify that this thesis entitled "Critical study of *'Vṛkṣāyurveda'* texts for the cultivation of Medicinal and Aromatic Plants (MAP)**"** submitted by C.G. Krishnamurthi bearing registration number 14HSPH02 in the partial fulfillment of the requirements for the award of Doctor of Philosophy in Sanskrit Studies (‘*Vṛkṣāyurveda*’) in the School of Humanities, carried out by him under my supervision and guidance.

This thesis is free from plagiarism and has not been submitted previously in part or in full to this or any other University or Institution for award of any degree or diploma.

Further, the student has the following publications before submission of the thesis for adjudication and has produced evidence for the same.

1. Journal paper titled *"Vrikshayurveda, a brief history from ancient times to present times"*, in The Journal of Sanskrit Academy, Hyderabad, Volume No. XXVI - 2019, ISSN No. 0976-089X, Page No. from 139 to 157, in December 2019.

And has made presentations in the following conferences –

1. *"Medicinal plant cultivation for Biodiversity conservation, Sustainability and Farmers' economic sustainability",* National seminar of Sustainable Development Goals and Building future India conducted by CSSEIP, School of Social sciences, University of Hyderabad and ICSSR-SRC (Indian Counsel for Social Science Research), Hyderabad, 26th to 28th March, 2019

2. Presented a Poster titled *Vṛkṣāyurveda based Medicinal Plant cultivation in Agroforestry,* XIV Agricultural Science Congress (International conference), conducted jointly by NAAS, ICAR and IARI, New Delhi, 20th to 24th February, 2019

3. *Introduction to Vṛkṣāyurveda,* Speech given at the monthly seminar of Sri Jayendra Saraswati Ayurvedic College, Chennai, 27th September, 2018

4. *"Prakaraṇasya tātparyāvadhārakatvam"*, 15th World Sanskrit Conference, IASS and Shilpakorn University, Bangkok, Thailand, 28th June to 2nd July, 2015

Further, the student has passed the following courses towards fulfillment of coursework requirement for Ph.D. –

Sl. No.	Course Code	Course Name	Credits	Pass/Fail
1	SK-801	Natural language processing	4	Pass
2	SK-711	Indian Grammatical Theories	4	Pass
3	SK-702	Padartha Vijnaanam	4	Pass
4	SK-803	Vrikshayurveda	4	Pass
5	HS-830	Dissertation related readings (Ayurveda)	4	Pass

_____

Supervisor:
Prof. J.S.R. Prasad
Department of Sanskrit Studies
School of Humanities
University of Hyderabad

_____

Head of the Department
Prof. J.S.R. Prasad
Department of Sanskrit Studies,
School of Humanities,
University of Hyderabad

_____

Dean, School of Humanities,
University of Hyderabad

Acknowledgment – कार्तज्ञ्यम्

First and foremost, I wish to register my sincere and heartfelt thanks and gratitude to Prof. J.S.R Prasad for kindling my interest in the vast ocean of Ayurveda health sciences, guiding me into the philosophy and ontology of Ayurveda, Nyāya, Dravya-Guṇa vijñāna, tantra-yukti and providing critical inputs, guidance and motivation throughout my Doctoral research.

I wish to offer my sincere thanks to Prof. Kavi Narayana Murthy, School of Computer sciences, and Prof. B. R. Shamanna, School of Medical Sciences, the Doctoral committee members and Prof. Korada Subramaniam retired doctoral committee member for guidance during my research program. I wish to thank them for their valuable inputs and help in terms of steering my research in the right direction. I am thankful for their critical evaluation of my research, periodical reports and progress by providing valuable inputs on time, without which this research work and dissertation wouldn't be possible.

I wish to register my sincere thanks to Prof. Amba Kulkarni who taught me and also guided me since my enrollment into Ph.D. at University of Hyderabad. I also wish to thank Prof. Shrinivasa Varakhedi, Vice Chancellor, Kavikulaguru Kalidas Sanskrit University, Nagpur, and Prof. L. Kumaraswamy, Head of Department (Retd.), Sanskrit dept., D.G Vaishnava college, Chennai, for teaching me and guiding me in the past during my studies of M. Phil – Sanskrit and M.A. – Sanskrit, respectively.

With the blessings of all my guides and teachers, I am fortunate to be treading on the studies of the vast ocean of Sanskrit studies, especially in the studies of Sanskrit '*śāstra*', in particular in the vast science and Indigenous Technical Knowledge (ITK) of India since time immemorial, that is '*Vṛkṣāyurveda*' – Which is the holistic science and art of Agriculture, Agroforestry, Botany, Water management, and Ecology, which is still in vogue as part of traditional agricultural practices in India

Finally, I dedicate all my efforts with my humble prostrations on the lotus feet of my Great Guru Bhagavan Sri Ramana Maharishi, immensity in form, for being the eternal guiding light.

C.G. Krishnamurthi

किंस्वित् वनम् क उ स वृक्ष आसीत् - ब्रह्म वनं ब्रह्म स वृक्षः ।

[What is forest and what is a plant – Forest is the (representation) universal immensity (in form), the tree is the universal immensity (in form)]

(*Ṛgveda* – 10.81.4; *Taittirīya brāhmaṇam* – 2.8.9.6)

॥ वृक्षः॥

वृक्षते आवृणोति भूमिम् । व्रियते लोकैः फलाद्यर्थम् । ततः च वृक्षः ।

That which covers the face of the earth and that which is sought by the world for food is 'Vṛkṣa' (*Niruktam*)

॥ आयुर्वेदः ॥

आयुषः वेदः । आयुः वेदयति । आयुः विद्यते अनेन । आयुः विन्दति अस्मात् ।
आयुरस्मिन् विद्यते च इति आयुर्वेदः ॥

The science which imparts knowledge of life is Ayurveda

(*Caraka saṃhitā' (1.30.23); Suśruta saṃhitā (1.1.14)*)

॥ वृक्षायुर्वेदः ॥

वृक्षादि-प्रसव-आरोप-पालनादि-कृति-विद्या ।

उपवन-दकार्गल-विज्ञान-तरु-रोपण-चिकित्सा-विधिः ।

वृक्षायुर्वेदयोगः इति वृक्षादि-रोपण-पुष्टि-चिकित्सा-वैचित्र्य-कृतिः ।

The education of the science of plants from germination, cultivation, maintenance, and to all the allied activities (is Vṛkṣāyurveda) – *Arthaśāstra*

The rules of Agroforestry, water management, plant growth and treatment (is Vṛkṣāyurveda) – *Vṛkṣāyurveda of Surapāla* and *Kṛṣiśāsana*

The union of planting, enrichment, treatment, growth and beautification of plants is Vṛkṣāyurveda-yoga – *Kāmasūtra*

Vṛkṣāyurveda is a holistic discipline of 'plant life sciences'.

Table of Contents

List of Tables

List of Figures

Scheme of diacritical marks & Transliteration

This thesis uses the following scheme of transliteration and this is as per the International Alphabet of Sanskrit Transliteration (IAST)

Devanāgarī	Transcription		Devanāgarī	Transcription
अ	a		क	ka
आ	ā		ख	kha
इ	i		ग	ga
ई	ī		घ	gha
उ	u		ङ	ṅa
ऊ	ū		च	ca
ऋ	ṛ		छ	cha
ऌ	ḷ		ज	ja
ए	e		झ	jha
ऐ	ai		ञ	ña
ओ	o		ट	ṭa
औ	au		ठ	ṭha
अं□	aṃ		ड	ḍa
अः	aḥ		ढ	ḍha
			ण	ṇa
			त	ta
			थ	tha
			द	da
			ध	dha
			न	na
			प	pa
			फ	pha
			ब	ba

		भ	bha
		म	ma
		य	ya
		र	ra
		ल	la
		व	va
		श	śa
		ष	ṣa
		स	sa
		ह	ha

Abbreviations

AAHF	Asian Agri-History Foundation
AFI	Ayurvedic formulary of India
CCRAS	Central Council for Research on Ayurveda Sciences
CIKS	Centre for Indian Knowledge Systems
CIMAP	Central Institute of Medicinal and Aromatic Plants Research
CIMH	Centre for Indian Medical Heritage
DMAPR	Directorate of Medicinal and Aromatic Plants Research
ENVIS	Environmental Information System, Ministry of Forests and Environment
FAO	Food and Agricultural Organization (Part of United Nations)
FRLHT	Foundation for Revitalization of Local Health Traditions
GAP	Good Agricultural Practices
GDP	Gross Domestic Production
GACP	Good Agricultural and Collection Practices
GFCP	Good Field Collection Practices
GMP	Good Medicinal Practices
ICAR	Indian Council for Agricultural Research
ICFRE	Indian Council of Forestry Research and Education
ICH	International Conference on Harmonization
ICMR	Indian Council for Medical Research
ITK	Indigenous Technical Knowledge
IUCN	International Union for Conservation of Nature
MAP	Medicinal and Aromatic Plants
NMPB	National Medicinal Plants Board
PCIM	Pharmacopoeia Commission of Indian Medicine and Homoeopathy
PHARMEXCIL	Pharmaceutical Export Promotion Council of India
QPM	Quality Planting Material - Seeds, Seedlings, Saplings, Stems, Tubers, etc.
VCSMPP	Voluntary Certification Scheme for Medicinal Plants Produce
WHO	World Health Organization

Abstract

Vṛkṣāyurveda is the traditional Indian science of agriculture and botany. It provides countless processes and methods evolved over 1000s of years, for the cultivation of various plants including food grain crops, vegetables, trees and medicinal plants. This Ph.D. thesis is the result of a detailed and critical study of the core texts of *Vṛkṣāyurveda* and several journal articles, reports and research papers for cultivation of medicinal plants using the time-tested, native agricultural practices of India.

The science of *Vṛkṣāyurveda* vide many treatises provides detailed methods for land selection, soil management, water management, seed treatment, planting, crop protection, harvest and storage. This critical study is done with a focus on identifying and presenting suitable methods from various *Vṛkṣāyurveda* texts for the cultivation of medicinal plants using appropriate inputs the 'medicinal efficacy' of the medicinal herb is well protected in addition to achieving better yields than conventional cultivation.

This thesis is spread over seven chapters with each chapter focusing on a specific aspect of *Vṛkṣāyurveda.* Starting with the statement, aim, objectives of the research, this thesis highlights the Vedic origins of the science of *Vṛkṣāyurveda*. Background of *Vṛkṣāyurveda* including its principles and its comparison to the modern farming methods are detailed along with the list of published and unpublished manuscripts of *Vṛkṣāyurveda*. Various agroforestry models and practices of *Vṛkṣāyurveda* are detailed for the cultivation of medicinal plants covering the full lifecycle including soil management to plant growth & protection to harvest and storage.

The key contribution of this thesis includes the cultivation protocol recommendations for the high priority medicinal herbs based on *Vṛkṣāyurveda* and Systems architecture of *Vṛkṣāyurveda* based on Systems biology model. Various international standards like WHO /FAO Good agricultural practices (GAP) which are to be adhered for MAP cultivation are also detailed. Finally this thesis establishes that the *Vṛkṣāyurveda,* methods are ideally suited for the sustainable cultivation and protection of medicinal plants.

Chapter 1: INTRODUCTION

The geography of India is a unique one with a culture which has been holding the limelight in the world for both science and sustainability for millennia. Despite being a populous country since time immemorial, India was largely self-sufficient in its ability to meet the food, fodder and medicinal needs internally for centuries. The foundation for this success and the long history of sustained leadership position in world economy has been its agriculture and animal husbandry. India's agriculture has an unbroken tradition of over 5000 years. This traditional agricultural practice in India not only supported the Indian population for centuries, but also provided food for a huge population of Cattle, Horses and Elephants. In addition, India's agriculture has been instrumental in establishing India's economic strength through the export of spices and medicinal plants in the erstwhile Silk Road covering most of Asia and Eastern Europe.

India's leadership position in the world economy through agriculture, textiles, spices and medicinal plants trade was very well researched and recorded by a number of Agriculture scientists and Economists. Dr. John Augustus Voelcker, the English agricultural chemist appointed by the British Empire also recorded the superior practices of Indian agriculture in his study report 'Report on the improvement of Indian agriculture' in 1893. India, had a share of 25% of global GDP, as noted by the British Economist Dr. Angus Maddison, in his magnum opus, 'The world economy: Historical statistics' in 2003 and also by Dr. David Clingingsmith, Economist of Harvard University in his research publication 'India's deindustrialization in 18^{th} and 19^{th} centuries' in 2005.

It is to be noted that, British when they established their empire in India, one of the first major activity was the establishment of Royal Botanical Garden (Botanical survey of India) in the erstwhile Calcutta in 1840 and documentation of all the herbal, botanical wealth of India. In addition, large scale cultivation of the medicinal plant *'Cinchona pubescens'* across India was also undertaken, spearheaded by the Botanist Sir George King, the first Director of Botanical survey of India. This was done mainly due to understanding of India's agricultural strengths particularly with respect to medicinal plant cultivation and processing.

Vedas, the literary wealth of human beings, are full of scientific wisdom with respect to human civilization and sustenance. Vedas were in existence much earlier to the advanced civilizations of Greeks and Romans. The Vedic literature is a storehouse of knowledge of the sciences of both physical and meta-physical in nature. Agriculture as the primary pursuit of human civilization was elaborated in a poetic and cryptic manner in the Vedas, among many other things.

In continuation of the Vedas, the seers of the *śāstra paramparā* (the holistic scientific lineage) codified this descriptive scientific knowledge into a branch of science. This scientific branch of codified traditional knowledge of Agriculture in India is known as *Vṛkṣāyurveda.* This science was expounded to a complete branch of studies and education for a very long time much before the times of Buddha, Kautilya, Asoka, etc.

It is indeed painful to witness the drastic changes in India, during the past 200 years, where most of the modern agriculturalists and scholars have lost touch with this traditional branch of agricultural science due to the

increased promotion of Western style agricultural education, practices and usage of chemicals resulting in systemic suppression of Traditional practices.

It is to be noted that prior to the introduction of British agricultural practices in India, the country was self-sufficient in production of Food products, Spices, Medicinal herbs, Fodder and Textiles. Despite the onslaught, many of the traditional agricultural practices survived and are still in practice in rural and tribal areas in India. Undoubtedly, many of these traditional practices have their roots in *Vṛkṣāyurveda*.

The agricultural production and productivity in the past were not only meeting the domestic demands, it was also being the cornerstone of India's economic might as a leading exporter of Spices, Herbs and medicinal products to several countries in the erstwhile Silk-road – the world's largest trading route which was spanning throughout Asia.

With the science and practices evolved over centuries, *Vṛkṣāyurveda* based agricultural methods are highly suitable, time-tested, organic, local and sustainable, and also helps in the conservation of Ecology and plant biodiversity.

The traditional Indian healthcare systems, i.e., Ayurveda, Siddha, etc. providing primary healthcare to over 70% of the population, stand on top the steady supply of herbal raw material. Currently, the medicinal plants and herbal wealth of India is dwindling day-by-day and therefore, the need for large scale cultivation of medicinal plants and herbs is more than ever.

This thesis establishes that, the philosophies, practices and techniques prescribed in various *Vṛkṣāyurveda* texts are most suitable for the cultivation of Ayurveda and Siddha medicinal plants and thereby protecting the traditional and primary healthcare systems in India.

In India, over 70% of the population depends on the traditional healthcare systems such as Ayurveda, Unani, Siddha and other herbal methods for primary healthcare due to cost effectiveness. These healthcare systems totally depend on Medicinal herbs, both cultivate and wild collected. Over 950 Medicinal and Aromatic Plants (MAP), which are being traded, form the core of these three traditional healthcare systems. According to the National Medicinal Plants Board (NMPB), Ministry of AYUSH, out of the total 950 common Medicinal plants that are in trade, 519 medicinal plants are sought after by Ayurveda medicinal system and 339 medicinal plants by Siddha medicinal system and 298 medicinal plants in Unani medicinal system.

Cost of healthcare is increasing day by day, it's therefore important to protect all kinds of traditional healthcare systems such as Ayurveda, Siddha and Unani to provide cost-effective healthcare to the masses. The core of these healthcare systems are the plant derived herbal drugs and medicinal plants that form the raw-material, need to be cultivated, protected and governed.

Out of the 519 Ayurveda medicinal plants, 252 are most sought after and are highly traded, with volumes reaching few millions of metric tons. Among the highly traded 252 Medicinal plants, only about 100 are currently under cultivation and the rest are sourced from the wild. With multifold increase in

demand, many medicinal plants are being indiscriminately collected from the wild and therefore are becoming endangered.

These nation level critical needs, have prompted Government of India in setting up a Pan-India board to govern, protect and promote the medicinal plant wealth of India, and thus born National Medicinal Plants Board (NMPB) in the year 2000. Since the inception, NMPB through its incentive schemes for the cultivation of Medicinal plants across India, from about 50 medicinal plants that were being cultivated in the year 2000, to now over 100 medicinal plants are being cultivated in large scale. However, both the number of medicinal plants under cultivation and their volume of cultivation are insufficient to meet the domestic and export demands of the medicinal plants requirements.

1.1 Research Statement

Large scale cultivation of Medicinal and Aromatic Plants (MAP) through *Vṛkṣāyurveda* methods is essential to protect the primary and traditional healthcare systems of India to provide cost effective herbal raw materials endowed with best medicinal efficacy in a sustainable manner.

1.1.1 The Aim

Vṛkṣāyurveda, India's traditional agricultural and plant life-science has several sustainable cultivation practices which are most suitable for the cultivation of Ayurveda and other AYUSH Medicinal and Aromatic plants. Many of these practices are superior to various contemporary methods. The aim of this research is to bring out those salient methods and practices for the cultivation of Ayurveda and other AYUSH Medicinal plants and herbs

1.1.2 Objectives

- To understand *Vṛkṣāyurveda* holistically by studying various texts with respect to the entire gamut of cultivation of food grains, vegetables, commercial crops and medicinal plants and all other aspects
- To document some of the best practices and inputs of *Vṛkṣāyurveda* towards familiarizing them to the larger agricultural research community
- To promote the cultivation of various botanical inputs of *Vṛkṣāyurveda* for soil management, seed treatment, water treatment, plant growth, plant protection, pest control and storage
- To evaluate the methods of *Vṛkṣāyurveda* with modern practices and to merge the best practices of both to arrive at an integrated practice oriented package of practices for AYUSH /NMPB high priority herbs cultivation
- To publish the thesis in book format for the purpose of integrated Medicinal plant cultivation using *Vṛkṣāyurveda* methods

1.1.3 Methodology

- This research is based on unearthing many ancient *Vṛkṣāyurveda* texts and evaluation of concepts from very ancient times towards their application in the current times
- The methodology includes first a review of literature from Vedic lore to the *Vṛkṣāyurveda* texts written as late as 18th century C.E. and also several research papers published by AAHF, CIKS, etc.
- Asian Agri-History Foundation has critically edited and published 6 *Vṛkṣāyurveda* texts and based on cross references in those texts and also in many economy /polity texts many of the older texts of *Vṛkṣāyurveda* texts were identified.
- The major texts of *Vṛkṣāyurveda* were critically studied to develop a holistic view of *Vṛkṣāyurveda*.

- Comparison of *Vṛkṣāyurveda* methods with many of ITK (Indigenous Technical Knowledge of Agriculture) practices and also from Vedic texts to establish the antiquity and '*śastra'* (scientific) lineage of *Vṛkṣāyurveda*
- The original Sanskrit agricultural terminologies need to be interpreted for present times; an attempt was made to create a small dictionary of various *Vṛkṣāyurveda* terms by cross referencing with Lexicons, '*nighanṭu*' (medicinal encyclopaedia) texts and Dictionaries.

1.2 Research statement in detail

Large scale cultivation of medicinal plants and herbs is essential for the protection of the medicinal raw-material for the traditional healthcare systems. However, cultivation of these medicinal plants in conventional agricultural methods is being ineffective due to the lack of medicinal efficacy and potency. Thus, large scale cultivation of medicinal plants using *Vṛkṣāyurveda* methods to ensure uniform supply of herbal raw material to the traditional herbal healthcare industries is proposed.

As referred earlier, it is also important to increase the number of cultivated plants, from the current level of 100 plants to over 150 plants based on current market conditions and demands within the next few years and finally all the 252 high volume and most traded medicinal herbs (NMPB Data 2018) in due course of the 519 Ayurvedic medicinal plants.

Finally, this thesis proposes that all these efforts should lead both the cultivars and the herbal healthcare industries to promote cultivation of all the important 519 Ayurveda medicinal plants, 139 Siddha medicinal plants and 298 Unani medicinal plants. This kind of a large cultivation movement across India, require medicinal plant nurseries, Quality Planting Materials (QPM) such as seeds, seedlings, saplings, soil management recommendations, etc.

This MAP cultivation movement also requires arriving at complete cultivation protocols and methods of preparing input materials – growth stimulants and pest control which are organic, cost-effective and locally available. This thesis proposes using various *Vṛkṣāyurveda* methods along with certain modern methods for such a large scale medicinal plant cultivation. This thesis also provides *Vṛkṣāyurveda* based cultivation protocol which includes soil selection, seed treatment, input materials and pest control methods for 35 high priority medicinal plants as per NMPB.

This thesis also highlights the methods of Protection of Medicinal efficacy (Active Principle) and Safety in Medicinal herbs by using *Vṛkṣāyurveda* methods through plant-specific natural /organic /herbal growth stimulants and pest control methods.

This thesis provides the *Vṛkṣāyurveda* methods Controlled cultivation of medicinal plants to ensure prevention of accidental and mistaken adulteration of Herbal products with unknown /non-medicinal /non-compatible medicinal herbs. Proper identification and safety through proper QPM control, controlled cultivation, harvest, and storage are also part of the overall process.

Adherence to WHO /FAO - GAP (Good Agricultural Practices) norms are critical, due to these norms are now universals and are applicable not just for exports but also for domestic consumption of herbal raw-material. In the Indian domestic market, apart from WHO standards, AYUSH /PCIMH, ICMR have also devised Standards for all various kinds of herbal medicines.

Therefore, this thesis also touches upon the various regulatory guidelines and norms that the medicinal plant cultivars need to be aware of and also adhere to. *Vṛkṣāyurveda* based cultivation methods, which are Natural, Organic and Economical and are specific to Plant types, geography, topography, seasons, land type, water and soil conditions are helpful to meet the regulatory guidelines.

As per International Union for Conservation of Nature (IUCN), World Wide Fund for nature (WWF), it is to be understood that indiscriminate collection of medicinal plants from the wild is pushing several medicinal plants species towards various levels of endangerment. Thus, only through cultivation of medicinal plants, prevention of forest plant wealth can be protected.

Widespread cultivation of medicinal plants is essential to ensure non-disruption of the manufacturing of a traditional poly-herbal medicinal formulation. Shortage of a single medicinal herb, can potentially disrupt the production of a particular medicine formulation which also contain many other medicinal herbs. Thus, cultivation also helps in limiting the wastage of the many other medicinal herbs. It is also possible to protect several Medicinal plant species' germ-plasms through bringing many wild plants under cultivation in different climatic and topographic conditions.

Vṛkṣāyurveda recommends that the cultivation of medicinal plants, to be done in '*upavana*' or '*ārāma*' (Agroforestry) and suitable lands and soil types. Agroforestry based farming can ensure less water usage with wide plant diversity in the agricultural field which ensures natural ecological balance.

This mimics the environment of wild (forests) and therefore the medicinal efficacy is protected.

Through the unique inputs and methods, *Vṛkṣāyurveda* can ensure better yield of agricultural produce including that of medicinal plants, therefore it is the most familiar, and cost-effective compared to all other methods of MAP (medicinal and aromatic plants) cultivation. Finally, cultivation using *Vṛkṣāyurveda* methods shall ensure the phytochemical signatures and Active ingredients of the cultivated medicinal plants are in conformance with the Pharmacopoeia and herbal monograph standards published by Pharmacopoeia Commission of Indian Medicine (PCIM) for various Ayurveda, Siddha and Unani herbs.

1.3 Herbal and Traditional healthcare in India

India, like many ancient civilizations depend on Medicinal plants as the basis for traditional healthcare system for millennia. More so the Indian healthcare traditions have the distinction of having a thoroughly codified system of medicine in particular the Ayurveda has the complete cycle from herbal raw-material to pharmacology to dietetics. In these healthcare systems, apart from the codification on the usage of medicinal plants for preventive and curative healthcare, 1000s of medicinal plants are codified in terms of botanical, morphological and pharmacological characteristics.

India is also unique in possessing a substantial amount of biodiversity of MAP (medicinal and aromatic plants) in the world, due to India's diverse tropical, topographical, agricultural, soil, water and climatic conditions.

As per *Ṛgveda*, each and every plant has got medicinal value and therefore all the plants were seen with reverence and were protected. In India, out of the total 17,000 identified plant species, 8,000 plant species have been found to have some medicinal value and out of these about 2,000 were used in traditional healthcare systems such as Ayurveda, Siddha, Unani and also in folk medicine. Some of these medicinal plant species are also being used as culinary spices, in many rural /local cuisines.

In addition to being medicines, many of these plants are consumed as nutraceuticals. Some are also used as cosmetics. Yet some are used in the preparation of medicinal Wines

1.4 Literature survey

वृक्षायुर्वेदफलं मनोहरं शास्त्रतः सिद्धम् [1]।

वृक्षायुर्वेद-विधिना व्याधितन्तु यथाक्रमम् ।
नीरुजं मानवः कृत्वा स्वर्गलोकम् अवाप्नुयात् [2] ॥

Plants are referred to as '*paśupati*', meaning the lord of all other life-forms in Veda. The above verses establish the ultimate truth that the discipline of *Vṛkṣāyurveda,* which is the combination of plant life science and agriculture, came from the Vedas for the purpose of protecting life on earth. It is also important to understand that this branch of science is the key for sustaining India's glory for centuries with respect to self-sufficiency and abundance of food, medicine, animal-husbandry and economy.

[1] Upavana vinoda 1.295

[2] Viṣṇudharmottara-purāṇa, Drumāropaṇanirūpaṇa 1.18

The following are the gist of the literature that were referred for this study and are categorized based on their topics.

1.4.1 History of Agriculture, Trade and Economy in Ancient India

Arthasāstra of Kautiya (Shama sastri, 1907) provides the details of the roles and responsibilities of agricultural superintendents in ancient times. In addition, cultivation, forest produce (medicinal plants), township planning, storage and trade were also dealt in detail. In addition, the importance of agriculture from multitude of angles including economic was studied.

Sukranīti (Sarkar. B. K., 1914 and Basu B.D., 1914) provides the details of Agriculture, Polity and administration in ancient India a few centuries later than Arthasāstra. Agriculture and Agronomy were dealt in a more detailed manner and was referred.

A Textbook on Ancient History of Indian Agriculture (Saxena RC, Choudhary SL, and Nene YL, 2009) referred with respect to India's agricultural history from the Vedic times, Vrikshayurveda times, medieval times till 18th century.

The world economy: Historical statistics (Maddison, 2004) studied the details the economic size and scale of trade, etc. in the erstwhile Silk road and also the share of India in global trade of Spice, MAP and textiles.

Agricultural and allied arts in Vedic India (Yegna Narayan Iyer, 1949), provides the detailed understanding on farming, crops, lands, urban life, etc. in ancient India.

Agricultural Heritage of India (Nene and Choudhary, 2002) and *Bridging Gap between Ancient and Modern Technologies to increase Agricultural Productivity* (Choudhary, Saxena and Nene, 2006)

1.4.2 Vṛkṣāyurveda texts

Nirukta, Krishishasana, Kāmasutra, Vācaspatya, Arthasastra, etc. for the nirvacana (definition) of the science of *Vṛkṣāyurveda*

The discipline of *Vṛkṣāyurveda*, which is the science of plant life and agriculture, is in practice for millennia, deals with entire gamut of agriculture. *Vṛkṣāyurveda* is a continuation of Vedas with respect to agriculture.

Ayurvedic cannons such as Caraka-saṃhitā and Suśruta-saṃhitā were also referred as they dealt with suitable land, soil types and also harvesting seasons for medicinal plants.

Original Sanskrit works and the English translations of the texts were referred for deeper understanding of Various topics such as land selection, seed treatment, soil management, preparing pits /beds for planting; watering, nourishment and fertilizers, pest control, plant diseases and protection; layout of gardens / Agroforest; ground water identification, water management, storage, etc

The texts referred for the present study are (1) Vrikshayurveda (The Science of Plant Life) by Surapala (Sadhale, 1996); (2) Vishvavallabha (Dear to the World: The Science of Plant Life) by Shri Mishra Chakrapani (Sadhale, 2004); (3) Kashyapiyakrishisukti - A Treatise on Agriculture by Kashyapa (Ayachit,

2002); (4) Varahamihira's Brihat Samhita (Subramania Sastri, 1946), for general agricultural and horticultural practices and plant inputs.

Texts such as (5) *Upavana vinoda (A Sanskrit treatise on Arbori-Horticulture) by Sharngadhara* (Majumdar G.P, 1925); (6) *Mānasollāsa Abhilaṣitārthacintāmaṇi of King Someśvara* (Shrigondekar G.K., 1961) are specifically referred for '*upavana*' - Agroforestry and horticultural processes and inputs

Treatises such as (7) *Vṛkṣāyurveda* of Parāśara (A Treatise on Plant Science) (Sircar and Sarkar, 1996) focuses on the botanical aspects of plant life-forms and was referred for plant morphological aspects.

Texts such as (8) *Krishi-Parāśara (Agriculture by Parashara)* (Sadhale, 1999) and (9) *Prācyabhāratīyam ṛitu vijñānam* (Tripāṭhī, 1971) deals with Agro-meteorology and were referred to understand the meteorological aspects of ancient Indian agriculture.

Texts such as (10) *Bhūgarbhajalajñānaśāstram (Groundwater identification) of Varāhamihira,* (Surkant Jha, 2005) and (11) *Saṃskṛtavāṅmaye Jalavijñānam* (Srikrishna Semval, 2001) were referred for ground water identification and water management.

Texts like (12) *Amarakoṣa of Amarasimha* (Vasudeva Sarma Pansikar, 2010) and (13) *Bhāvaprakāsa nighaṇṭu of Bhāvamiśra* (Chunekar, 2015), were referred for various Sanskrit terminologies and synonyms with respect to ancient Indian agriculture.

The text (14) *Lokopakara* – English translation, focus on best procedures to be followed for cultivation of various agricultural crops and plants. It also details of classification of land, forests in ancient India, different parts of plants, seeds and seedlings. (Ayangarya V. S., 2006).

The importance of seed health in ancient and medieval times and its relevance to the present-day agriculture has been elucidated by Nene (2000). Vrksayurveda and the art of growing plants (Suresh et al., 2013), and other similar texts and articles were referred for this thesis.

Indian scientific traditions (Unithri, 2003) provides a detailed account of Agriculture and Vastu in ancient India, was studied.

Scientific Knowledge in Sanskrit Literature (Trikha. N., 2009) provides a detailed coverage of the various aspects of Plant taxonomy, propagation, morphology, etc. taken from Ayurveda and Vrikshayurveda texts. This text was studied and referred for this thesis

1.4.3 Vedic literature

The following Vedic texts were studied ad referred and relevant Veda sukta portions specific to agriculture are added in this thesis

'Ṛgveda' – (Sanskrit) with commentary 'vedārtha-prakāśa' of 'Śri. Sāyaṇācārya'

'Yajurveda' – (Sanskrit) with commentary 'vedārtha-prakāśa' of 'Śri. Sāyaṇācārya'

'Atharvaveda saṁhitā'

Agriculture and Animal Husbandry in the Vedas (Kansara 1995)

1.4.4 Ayurveda literature

The Ayurvedic cannons such as *Caraka Saṃhitā, Suśruta Saṃhitā* and *Nigaṇṭu* (Ayurvedic materia-medica) texts detail the '*saṅgraha-kāla'* (harvest & collection) the ideal season and times for various medicinal plant harvest and also storage methods – these details have been referred and used.

Dravyaguṇa vijñāna (Sharma P.V., 2013), was referred to understand the dravya-guṇa (pharmacological) details of the various plant nutrition and pest control substances

Rasa-panchaka (Dhyani S.C., 2008)

'Ayurvedic characterization of bio pesticides' (Ahuja Subash, et. al., 2007)
'Vrikshayurveda in the context of Ayurveda' (Sadhale. N, Dave. S, 2006)

'AYUSH medicinal plants' NMPB Presentation 2017, Live Earth India, etc. (http://www.indiahomeclub.com/botanical_garden/medicinal_plants_uesd_in_ays.html), CIMAP Data

1.4.5 Indigenous Technical Knowledge in Agriculture

'An inventory of the various ITK (Indigenous Technical Knowledge) in Agriculture in India', in 5 volumes published by Indian Council for Agricultural Research (ICAR), New Delhi (Das et al., 2004), was the major

reference material for the comparison of the ITK practices and *Vṛkṣāyurveda* also referred for this study.

The Centre for Indian Knowledge Systems (CIKS), Chennai, based on their work on Vrikshayurveda and other traditional farmer's practices, has published a number of books dealing with various aspects of traditional agriculture (Vijayalakshmi and Sundar, 1993);

1.4.6 Medicinal plants sector studies in India

A study of Indian Medicinal and aromatic plants market in 2016-17 was conducted by Indian Council of Forestry Research and Education (ICFRE) along with National Medicinal Plants Board (NMPB)

Pharmaceutical Export Promotion Council of India (PHARMEXCIL), Ministry of Commerce., about the Indian Medicinal Plants and herbal raw material exports data

The importance of medicinal plants for primary healthcare in India, and the nation-wide promotional activities along with SMPB (State medicinal plants boards) with respect to cultivation, incentives, and sustainable usage is referred from the NMPB website (NMPB, 2019).

Lele R. D., Dr., '*Plant origin of some of the important modern drugs*' (2010)
The publication by Ved and Goraya (2008) gives the trade related information with respect to herbal demand, raw drug manufacturers, and the growth of medicinal plants.

Phytochemical signatures and Active ingredients of the cultivated medicinal plants are in conformance with the Pharmacopoeia and herbal monograph standards published by Pharmacopoeia Commission of Indian Medicine & Homoeopathy (PCIMH) for various Ayurveda, Siddha and Unani herbs.

Details of Herbal monographs - AYUSH /PCIMH, ICMR websites

'Classical approach to collect medicinal plants – A prudent view in optimizing pharmacological affluence' Mamatha et al. (2017)

1.4.7 Manuscript catalogs referred

- New Catalogus catalagorum publications of University of Madras;
- IGNCA (Indira Gandhi National Center for Arts);
- National Manuscripts Mission, manuscript index,
- 'A check list of Sanskrit medical manuscripts', CCRAS, National Institute of Indian Medical Heritage (NIIMH), 1972.

1.4.8 Research reports

Research reports on *Vṛkṣāyurveda* based inputs and due to which the improvement in active ingredients (medicinal efficacy) by AAHF and others

Several experiments have been done in the past decade on the usage of *Vṛkṣāyurveda* based inputs and methods for the cultivation of various food grain crops and vegetable crops such as Paddy, Mung bean, Brinjal, Tomato, Okra, Peas, etc. The results of the experiments have been very positive and encouraging. All of these research articles are published in peer-reviewed journals and are available for open access in the Internet.

Similarly, the following published research reports highlight the effects of '*kuṇapa jala*' and other *Vṛkṣāyurveda* inputs for growing Medicinal plants with details on the medicinal efficacy (active principle and active ingredient) of the grown medicinal plants based on laboratory testing. The details are given in the table below:

Researcher	Medicinal plant, Research and Results	Publication
Gireesh M. Ankad, Jagadishchandra Hiremath, R.T. Patil, H.J. Pramod, Harsha V. Hegde 2017	**Research**: Nutrient analysis of Kunapa jala and Pancha gavya and their evaluation on germination of Ashwagandha (Withania somnifera Dunal) and Kalamegha (Andrographis paniculata Nees.) seeds: A comparative study Vrikshayurveda, has clearly outlined a systematized agricultural practice that insisted the use of Kunapa jala (KJ) and Pancha gavya (PG). The nutrient contents and germination parameters of KJ and PG were compared with other groups namely control (CONTR), farmyard manure (FYM), humic acid (HA) and NPK. **Results**: The pH and EC were 5.793, 2.653 dS/m and 5.584, 2.216 dS/m for KJ and PG respectively. KJ possess highest nutrient contents followed by PG. The germination parameters revealed the better activity of NPK followed by KJ, PG, HA, FYM and CONTR. KJ and PG were found to be good in nutrient contents and were found to be effective on studied germination parameters of Ashwagandha and Kalamegha seeds	Journal of Ayurveda and Integrative Medicine, 2017
Asha KV 2006.	**Research**: '*Lāṅgalī*' (*Gloriosa superba* Linn.), Comparative pharmacognostic and pharmacological evaluation of Langali grown with Kunapajala	Ph D. Thesis, Gujarat Ayurved University. Jamnagar, India.

	Result: *Kunapajala* treated *'lāṅgalī'* plants exhibited excellent result in terms of general growth of the plants and fruiting when compared to control group and chemical fertilizer group. Even though the yield of tuber was not significant enough, one of its active ingredient 'Colchicine' (methanol extract) was found in higher amount in *Kunapajala* treated plants.	
Brajeshwar 2002	**Research**: 'Effect of different agronomic practices on Senna (Cassia angustifolia Vahl.)' **Result**: Senna (Cassia angustifolia Vahl.) was grown by using both laboratory prepared and commercial Kunapajala. It was sprayed at the rate of 2 ml. per liter of water. Readings taken after 45 days of sowing showed significant results in parameters like height of the plants (in centimeters), enhancement of leaf area index etc. Leaves being the main organ containing Sennoside, the active ingredient, Kunapajala was helpful in substantially increasing it. The study also showed that fertilizer treated plants flowered very early but Kunapajala treated plants have delayed flowering resulting in harvesting of more foliage. Total Sennoside content per plant (in grams) was analyzed after 70 days which showed that Senna grown using laboratory prepared Kunapajala showed excellent results when compared to chemical fertilizer and control group.	M.Sc. Dissertation, Gujarat Ayurved University, Jamnagar, India
Vijayalakshmi, 1997	**Research**: Enhancement of growth and flowering in Balsam *(Impatient sultana)* was studied after applying *Kunapajala* decoction.	Compas CIKS Journal

	Result: The results showed that the response to *Kunapajala* was found favorable in all three stages of application i.e. germinative, vegetative and flowering stages	
P. Srimathi, N. Mariappan, L. Sundaramoorthy and M. Paramathma 2013	**Research**: 'Efficacy of Panchagavya on seed invigoration of biofuel crops' **Result**: Jatropha curcas and Pongamia pinnata seeds fortification with Panchagavya at 2 and 5% for 16 and 8 h, respectively of soaking had highest invigoration effect than water soaking and control. Thus, this study may suggest that Panchagavya application is one of the traditional, eco-friendly and low cost technique to enhance the better seed invigoration and promote the successful large scale afforestation in tree species.	Academic Journals,

Table No. 1.1 Research reports of *Vṛkṣāyurveda* methods

1.4.9 Environmental factors influencing Medicinal efficacy

Caraka-saṃhitā one of the oldest Ayurvedic cannon gives a detailed account of the environmental factors and the medicinal efficacy from the medicinal efficacy standpoint in the book *Kalpasthāna* and was referred for this thesis.

Texts and portions of modern research findings provide details of various environmental factors such as Edaphic, Allelopathic, etc. with respect to the medicinal efficacy (*vīrya*) of medicinal plants and were referred to diagrammatically consolidated representation of these details.

1.4.10 Endangered Medicinal plant databases

International Union for Conservation of Nature (IUCN), World Wide Fund for nature (WWF), it is to be understood that indiscriminate collection of

medicinal plants from the wild is pushing several medicinal plants species towards various levels of endangerment.

Red list (critically endangered) as per published data from the ENVIS (Environmental Information System), Ministry of Forests and Environment, Government of India

FRLHT CD on endangered medicinal plants in India.

ENVIS (Environmental Information System), Ministry of Environment, Forests and Climate change – Critical data referred with respect to medicinal plant wealth, ecology, desertification and threat status of wild medicinal plants.

1.4.11 Papers on Cultivation, collection and conservation of Medicinal plants

The Medicinal Plants Sector in India: A Review by Jason Holley and Kiran Cherla (1998) International Development Research Centre (IDRC)

'Report of the training Programme on Collection, processing and storage of seeds of medicinal plants and management of Seed Centre' (2009), Kerala Forest Research Institute (KFRI).

https://vikaspedia.in/agriculture/crop-production/package-of-practices/medicinal-and-aromatic-plants details of cultivation practices for various medicinal plants.

Training Manual on 'Conservation and Collection of Seed Germ-plasm of Medicinal and Aromatic Plants' of NBPGR, New Delhi (2009)

Annual reports of CIMAP (Central Institute of Medicinal and Aromatic Plants) and DMAPR (Directorate of Medicinal and Aromatic Plants Research), CCRAS (Central Council of Research on Ayurvedic Sciences), for the year 2015 till 2019.

CIMH (Center for Indian Medical Heritage) CD on medicinal plants

GAP manuals of DMAPR (Directorate of Medicinal and Aromatic Plants Research) for Aloe vera, Ashvagandha, Patchouli, Safed musali and Vettiver

Cultivation of Selected Medicinal Plants - NMPB (2004) provide propagation and cultivation protocols of selected medicinal plants

Requirement of Important Raw Drugs for Ayurvedic Medicines, Estimation of Planting Materials, Developing Protocols for Collection, Grading and Seed Storage for Cultivation of Medicinal Plants of Kerala (Sashidharan and Pandalai (2007)
'Fumigation of plants in Vrikshayurveda', Nene (2014)

1.5 Thesis Outline

Chapter 1 provides the introduction to the overall thesis with the research statement, aim, objectives, research statement, methodology, review of literature, thesis outline, discussion and conclusion. This chapter also highlights the need for such a research and its contemporary relevance.

Chapter 2, highlights the agriculture and ecology in Vedic and Itihasa texts' literary focus on agriculture along with certain key Vedic passages relating to cultivation, ploughing, pest control, Goddess of forests and Ecology and prayers to the lord of agriculture for good yields. In addition, certain key passages are also given from Ramayana and Mahabharata specific to agriculture and botany. These are highlighted to delve deeper to understand the importance for agriculture since ancient days and also to understand the higher principles of sustainability.

Chapter-3 provides a detailed introduction to *Vṛkṣāyurveda* including its philosophies, principles and overall outlook. This covers right from the śāstra based purpose of *Vṛkṣāyurveda,* its literary wealth, connection with Ayurveda, published and unpublished manuscripts of *Vṛkṣāyurveda,* its relevance in contemporary agriculture, *Vṛkṣāyurveda* as the indigenous technical knowledge of Agriculture in India and finally its comparison with various contemporary organic farming methods.

Chapter 4 of the thesis highlights the various agricultural and agroforestry practices right from agricultural Land classifications such as Agricultural fields for the cultivation of food crops and '*upavanam*' (Agroforestry) model for the cultivation of all horticultural crops including medicinal plants. This chapter also lists several types of medicinal forests, sacred groves and community forests that were maintained in India. These community medicinal forests were modeled on *Vṛkṣāyurveda* model of '*upavanam*' (Agroforestry) and were the source of medicinal raw material in ancient and medieval India.

Chapter 5 details the cultivation of medicinal plants in *Vṛkṣāyurveda* methods. Starting with land selection for medicinal plant cultivation from the key *Vṛkṣāyurveda* texts to soil management, soil fertility, water management, rain patterns, irrigation, seed management, seed treatment, cultivation, harvest, medicinal plant forests, Ayurveda and *Vṛkṣāyurveda,* medicinal plant nutrition, pest control and plant protection.

Chapter 6 provides the critical outlook for medicinal plant cultivation. This chapter covers various details and the contemporary challenges in medicinal herb cultivation and contract farming. This also includes WHO and AYUSH benchmarks for the practice of Ayurveda. This chapter also covers various international standards and regulatory guidelines of herbal medicines right from WHO specifically with respect to the cultivation of medicinal herbs. This chapter also highlights the herbal ingredients testing protocols and ICMR, NMPB guidelines on the cultivation of medicinal plants.

Chapter 7 provides the Package of practices, i.e.: the recommended *Vṛkṣāyurveda* inspired cultivation protocols for the widespread cultivation of medicinal plants by farmers, communities and urban medicinal forest managers. This chapter highlights the 10 critical medicinal plants with high demand as per the NMPB list and their specific cultivation methods right from soil requirement, seed preparation, growth, harvest, etc. to get the best yield as well as good medicinal efficacy. Also this chapter provides the integrated process of *Vṛkṣāyurveda* and modern methods.

Conclusion – provides details on in-situ and ex-situ cultivation and conservation of medicinal plant wealth and a summary of the key recommendations. This chapter conclusively highlights the need for

Vṛkṣāyurveda as the chosen method for the protection of medicinal plant wealth of India as well as the primary healthcare of India.

1.6 Discussion

This doctoral research and the resultant thesis is an earnest effort to study, understand and bring out the role of '*Vṛkṣāyurveda',* in particular with respect to the cultivation of medicinal plants, aromatics and spices, which form the sources of medicine and healthcare in India for centuries. In this context, for deeper understanding of the multiple factors for the continued availability of medicinal plants for centuries. This thesis cross-referred many ancient literary works along with modern research reports, research papers and journal articles to arrive at some of the suitable cultivation protocols for the high-demand medicinal plants

1.7 Conclusion

It is essential to adapt to many of the time tested methods of *Vṛkṣāyurveda* for the large scale cultivation of many of Medicinal plants which are not in cultivation as on date, mainly due to the lack of cultivation protocols and sustainable methods in the modern agricultural and also to protect their medicinal efficacy during cultivation. This thesis proposes and also outlines some of *Vṛkṣāyurveda* methods for such a cultivation exercise

Chapter 2: Agriculture and Ecology in the Vedas and *Itihāsa*'

2.1 Farming

अक्षैः मा दीव्य कृषिमित्कृषस्व वित्ते रमस्व बहुमन्यमानः ।
तत्र गावः कितवः तत्र जायाः तन्मे विचष्टे सवितायमर्यः[3] ॥

Do not gamble or waste time, Oh, gambler, engage in agriculture; rejoice with what you earn from the field. Oh thinker, life is verily in farming. 'Savitṛ' (Sun) the creator of all these has revealed this secret.

कृषिन्नित्फाल आशितं कृणोति यन्नध्वानमप वृङ्क्ते चरित्रिः ।
वदन् ब्रह्मावदतो वनीयान् पृणन्नापिर पृणन्तमभिष्यात्[4] ॥

The ploughshare furrowing the field provides food to the cultivar. A man traveling along the path of enterprise acquires wealth through his actions. A Brahman expounding Veda is better than the one who is not. Thus, let the man who cultivates and gives become the kinsman and not the one who doesn't share.

महि क्षेत्र पुरश्चन्द्र विविद्वानादित्सखिभ्यश्चरथं समैरत् ।
इन्द्रो नृभिरजनद् दीद्यानः साकं सूर्यमुषसं गातिमग्निम्[5] ॥

Agriculture, land and home, are the source of wealth prosperity and happiness in married life. People rejoice with abundance produce and wealth in this world and the Sun is praised for the agriculture.

[3] Ṛgveda 10.34.13

[4] Ṛgveda 10.117.7

[5] Ṛgveda 3.31.15

2.2 Cultivation Mantra (क्षेत्रकर्षणमन्त्रः)

वीर्यसम्मितः । वेणुना वि मिमीते । आग्नेयो वै वेणुः । सयोनित्वाय । यजुषा युनक्ति । यजुषा कृषति । व्यावृत्त्यै । षड्गवेन कृषति । षड् वा ऋतवः । ऋतुभिर् एवैनं कृषति । यद् द्वादशगवेन संवत्सरेणैव। इयं वा अग्नेर् अतिदाहाद् अ बिभेत् । सैतद् द्विगुणम् अपश्यत् कृष्टं चाकृष्टं च[6] ॥

Cultivation is through the plough; fire is the plough as both came from the single act of sacrifice. Through sacrifice this is enjoined, through sacrifice this ploughing happens for life's process and sacrifice. Through the six oxen – the six seasons ploughing happens. Through the twelve oxen – the 12 months of the year ploughing happens. This produce is to satisfy the thrust of the fire (hunger). This is verily of two types cultivated and non-cultivated

2.2.1 Ploughing

युनक्त सीरा वि युगा तनुध्वं कृते योनौ वपतेह बीजम् ।
गिरा च श्रुष्टिः सभरा असन्नो नेदीयेत् सृण्यः पक्वम् एयात्[7] ॥

Harness the yokes and fasten well the traces. Sow seed in the formed furrow. With sweet song may we find hearing fraught with plenty and ripened grain approach near the sickle.

शुनंसुफाला वि तुदन्तु भूमिं शुनं कीनाशा अनुयन्तु वाहान् ।
शुनासीरा हिवषा तोशमाना सुपिप्पला औषधीः कर्तमस्मै[8] ॥

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[6] Krishna-Yajurveda, Taittiriya saṃhitā 5.2.5

[7] Śukla-Yajurveda 12.68

[8] Śukla-Yajurveda 12.69

Let the plough turn up the agricultural field in happiness and let the hard-working cultivars go prosperous, let the prosperous plough and cultivate the soil, let air and sun shower the earth with water, cause our plants bear abundant fruit.

शुनं वाहाः शुनं नरः शुनं कृषतु लाङ्गलम् ।
शुनं वरत्रा बध्यन्तां शुनमुष्ट्रामुदिङ्गय[9] ॥

Let there be prosperity for the cultivars, prosperity for the all the people, let the plough bring happiness, let the strong oxen be happy, let the transportation camels be happy.

2.2.2 Pañca-sūktam (Five Hymns)

- *Camakam*

व्रीहयश्च मे यवाश्च मे माषाश्च मे तिलाश्च मे मुद्गाश्च मे धल्वाश्च मे प्रियङ्गवाश्च मे अणवश्च मे श्यामाकाश्च मे नीवाराश्च मे गोधूमाश्च मे मसूराश्च मे यज्ञेन कल्पन्ताम्[10] ।

May the rice be for me, may the barley be for me, may the pulses and beans be for me, may sesame and grains be for me, may kidney beans be for me, may vetches be for me, may barnyard millet be for me, may wild rice be for me and may wheat and lentils be for me. May all these grains prosper me and be procured through the skill and process of agricultural science.

अश्मा च मे मृत्तिका च मे गिरयश्च मे पर्वताश्च मे
सिकताश्च मे वनस्पतयश्च मे यज्ञेन कल्पन्ताम्[11] ।

[9] Śukla-Yajurveda 12.70

[10] Yajurveda 18.12

[11] Yajurveda 18.13

May the minerals for me, may the hills be for me, may the mountains be for me (ecological order /balance), may the sands be for me, may the plants be for me, all this indeed sustain through sacrifice.

वाजश्च मे प्रसवश्च मे[12] ।

May horses be there for me; may prosperity be for me.

सूश्च मे प्रसूश्च मे सीरं च मे लयश्च म ऋतं च मे ऽमृतं च मे[13] ।

May good yield be for me, may prosperity be for me, may plough be for me, may absorption be for me, may water be for me, may elixir be for me.

कृषिश्च मे वृष्टिश्च मे जैत्रं च म औद्भिद्यं च मे[14] ।

May agriculture be for me, may good rains be for me, may victorious be for me, may plants be for me.

2.3 *Kṣetrapati sūkta* (Lord of Agricultural fields)

क्षेत्रस्य पतिना वयं हितेनेव जयामसि । गामश्वं पोषयित्न्वा स नो मृळातीदृशे[15] ॥१॥

We invoke the lord of kṣetra, by whose grace indeed we prosper. He propels, nourishes and protects us.

क्षेत्रस्य पते मधुमन्तमूर्मिं धेनुरिव पयो अस्मासु धुक्ष्व ।
मधुश्चुतं घृतमिव सुपूतमृतस्य नः पतयो मृळयन्तु ॥२॥

[12] Yajurveda 18.14

[13] Yajurveda 18.15

[14] Yajurveda 18.17

[15] Ṛgveda 4.57.1-8

O lord of the kṣetra, with the sweet waves of nature's bounty, may you enrich our fields like how the Cow mother nourishes the calf and with the sweetness of cosmic order nourish us.

मधुमतीरोषधीर्द्याव आपो मधुमन्नो भवत्वन्तरिक्षम् ।
क्षेत्रस्य पतिर्मधुमान्नो अस्त्वरिष्यन्तो अन्वेनं चरेम ॥३॥

May the plants be sweet and enriching, may the water and sky be sweet, may the lord of the kṣetra be sweet to us, and we worshipers of him follow thy footsteps.

शुनं वाहाः शुनं नरः शुनं कृषतु लाङ्गलम् ।
शुनं वरत्रा बध्यन्तां शुनमष्ट्रामुदिङ्गय ॥४॥

May there be prosperity for the oxen, prosperity for the people, prosperity for the farmer, may the plough bind prosperity for all.

शुनासीराविमां वाचं जुषेथां यद्दिवि चक्रथुः पयः ।
तेनेमामुप सिञ्चतम् ॥५॥

May the oxen and the plants, prosper through the god who governs clouds and rains be pleased and shower the field.

अर्वाची सुभगे भव सीते वन्दामहे त्वा ।
यथा नः सुभगाससि यथा नः सुफलाससि ॥६॥

O goddess the harvest we worship you, you be favorable to us and nourish us with abundant produce.

इन्द्रः सीतां निगृह्णातु तां पूषानु यच्छतु ।
सा नः पयस्वती दुहामुत्तरामुत्तरां समाम् ॥७॥

May Indra take care of the goddess of harvest and may enrich and sustain her, may the goddess of harvest yield us with abundant produce.

शुनं नः फाला वि कृषन्तु भूमिं शुनं कीनाशा अभि यन्तु वाहैः ।
शुनं पर्जन्यो मधुना पयोभिः शुनासीरा शुनमस्मासु धत्तम् ॥८॥

Prosperity for us, fruits of our actions be realized, may there by prosperity for the earth, may the oxen attain welfare, May the gift of the rain God through sweet showers bring prosperity, and may the rain God be happy with our sacrifices.

2.4 *Kṛṣi-sūkta* (Agriculture Hymn)

सीरा युञ्जन्ति कवयो युगा वि तन्वते पृथक् ।
धीरा देवेषु सुम्नयौ[16] ॥१॥

Wise and devoted to the Devas the skillful men bind the plough-ropes fast, and lay the yokes on either side.

युनक्त सीरा वि युगा तनोत कृते योनौ वपतेह बीजम् ।
विराजः श्नुष्टिः सभरा असन् नो नेदीय इत्सृण्यः पक्वमा यवन् ॥२॥

Lay on the yokes and fasten the furrow, sow the seed within it. The great spirit shower us with plenty (of produce). Let the ripe grain grow tall near to the harvest sickle.

लाङ्गलं पवीरवत्सुशीमं सोमसत्सरु ।
उदिद्वपतु गामविं प्रस्थावद्रथवाहनं पीबरीं च प्रफर्व्यम् ॥३॥

The plough-share that binds the plough brings us happiness, furnished with goodness. Blessed with a cow, a sheep, and oxen to draw the plough.

[16] Atharva-veda, Śauṇaka saṃhitā, कृषिसूक्तम् 3.17.1-9

इन्द्रः सीतां नि गृह्णातु तां पूषाभि रक्षतु ।
सा नः पयस्वती दुहामुत्तरामुत्तरां समाम् ॥४॥

May Indra press the plough deep, may the plough be guarded by Pūshan. May the plough bring out the produce and yield (milk) year after year.

शुनं सुफाला वि तुदन्तु भूमिं शुनं कीनाशा अनु यन्तु वाहान् ।
शुनासीरा हविषा तोशमाना सुपिप्पला ओषधीः कर्तमस्मै ॥५॥

Let the plough turn up soil, let the peasants happily drive the oxen. Pleased with our offerings, let Suna and Sira make the plants bring out abundant yield.

शुनं वाहाः शुनं नरः शुनं कृषतु लाङ्गलम् ।
शुनं वरत्रा बध्यन्तां शुनमष्ट्रामुदिङ्गय ॥६॥

May our steers be happy and may our workers be happy. May the plough turn the soil happily, let the men happily drive the goad.

शुनासीरेह स्म मे जुषेथाम् ।
यद्दिवि चक्रथुः पयस्तेनेमामुप सिञ्चतम् ॥७॥

Suna and Sira, welcome to this land and bring out the milk of produce that is made in heaven. Bestow us with good yield.

सीते वन्दामहे त्वार्वाची सुभगे भव । यथा नः सुमना असो यथा नः सुफला भुवः ॥८॥

May the auspicious produce come to us, we venerate you. May you bless us and bring us fruits abundantly and prosperity.

घृतेन सीता मधुना समक्ता विश्वैर्देवैरनुमता मरुद्भिः ।
सा नः सीते पयसाभ्याववृत्स्वोर्जस्वती घृतवत्पिन्वमाना ॥९॥

May I be blessed by Visva-devas and the winds, with good produce and be bestowed with ghee and honey. Turn this land into wealth of milk. O Sita enrich us with your yield.

2.5 *Kṛmi-sūkta* (Agricultural pests and their control)

This sūkta of Atharva veda provides us with a list of botanical pest control methods in a cryptic and poetic style. Plants and their botanical extracts are good pest repellents, such as Ajaśṛngī (Gymnema sylvestre), Guggulū (Commiphora mukul), Pīlā (Salvadora persica), Naladī (Nardostachys grandiflora), Aukṣagandhi (Fatatus paniculata), Pramandanī, Aśvattha (Ficus religiosa), Nyagrodha (Ficus bengalensis), Mahāvṛkṣa (Euphorbia tirucalli), Sikhaṇḍī (Jesseminum oriculatum), Preṅkhā, Haritakā (Terminalia chebula), Arjunā (Terminalia arjuna), Apāmārga, Aghāta (Achyranthes aspera), Karkarī, Ayasmayī (Aloe vera Toarn), Hiraṇyaparṇā /Hiraṇyayī, Arāṭakī (Odina wodiar), Muṣka (Simplocos racemosa), etc.

Many of these plants can also be used as inter-crops in Agroforestry and Medicinal plant gardens. In addition, these plants themselves are Medicinal plants and many are used in Ayurveda.

त्वया पूर्वमथर्वाणो जघ्नू रक्षांस्योषधे ।
त्वया जघान कश्यपस्त्वया कण्वो अगस्त्यः[17] ॥१॥

O Plant, in olden times the Atharvan sages protected by driving away the pests. Kaśyapa, Kaṇva and Agastya too did the same.

[17] Atharva-veda कृमिसूक्तम् 4.37.1-6

त्वया वयमप्सरसो गन्धर्वांस्चातयामहे ।
अजशृङ्ग्यज रक्षः सर्वान् गन्धेन नाशय ॥२॥

With yourself we repel all the pests, O Ajaśṛngī (plant), may you chase all the pests. Let all pests to run away due to your smell

नदीं यन्त्वप्सरसोऽपां तारमवश्वसम् ।
गुल्गुलूः पीला नलद्यौक्षगन्धिः प्रमन्दनी ।
तत्परेताप्सरसः प्रतिबुद्धा अभूतन ॥३॥

Let the pests, puffed away, go to the river, to the ford, Guggulū, Pīlā, Naladi, Aukṣagandhi, Pramandinī, etc. you all have become effective in driving away the pests.

यत्राश्वत्था न्यग्रोधा महावृक्षाः शिखण्डिनः ।
तत्परेताप्सरसः प्रतिबुद्धा अभूतन ॥४॥

Where the great trees such as Aśvattha and Nyagrodha with their leafy crests, there the pests shall be driven away.

यत्र वः प्रेङ्खा हरिता अर्जुना उत यत्राघाताः कर्कर्यः संवदन्ति ।
तत्परेताप्सरसः प्रतिबुद्धा अभूतन ॥५॥

Where there are herbs such as Preṅkhā, Hartā, Arjunā, Aghāta, Karkarī, etc. there the pests shall be driven away.

एयमगन्न् ओषधीनां वीरुधां वीर्यावती ।
अजशृङ्ग्यराटकी तीक्ष्णशृङ्गी व्यृषतु ॥६॥

Let the herbs Ajasṛngi, Arāṭakī, Tīkṣṇaśṛngī penetrate the pests like Indra's thunderbolt and drive them away.

2.6 Ecology in The Vedas

2.6.1 Oṣadhi sūkta – Plants as mother of all other life-forms

या ओषधीः पूर्वा जाता देवेभ्यस्त्रियुगं पुरा ।
मनै नु बभ्रूणामहं शतं धामानि सप्त च[18] ॥

Those plants which existed before these gods before three eras are the protector of cows and are having 100s of seats and also 7 layers.

शतं वौ अम्ब धामानि सहस्रमुत वो रुहः ।
अधा शतक्रत्वो यूयमिमं मे अगदं कृत[19] ॥

Oh, dear Mother! Hundreds are your seats and thousands are your channels/branches.

ओषधीरिति मातरस्तद्वो देवीरुप ब्रुवे ।
सनेयमश्वं गां वास आत्मानं तव पूरुष[20] ॥

These plants are indeed goddesses as I proclaim, due to which all life-forms, cows, horses live and the 'ātmā' is the other half of them.

यत्रौषधीः समग्मत राजानः समितावि‍व ।
विप्रः स उच्यते भिषग्रक्षोहामीवचातनः[21] ॥

Where the plants are abundance there the kings are strong, like they are together. The one who protects the plants, is a scholar, healer, destroyer of evil.

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[18] Ṛgveda, Oṣadhi sūkta 10.097.01

[19] Ṛgveda, Oṣadhi sūkta 10.097.02

[20] Ṛgveda, Oṣadhi sūkta 10.097.04

[21] Ṛgveda, Oṣadhi sūkta 10.097.06

2.6.2 Nature – The Mother

यन्तु नदयो वर्षन्तु पर्जन्याः सुपिप्पला ओषधयो भवन्तु । अन्नवताम् ओदनवताम् आमिक्षवताम् एषां राजा भूयासम् ॥ ओदनमुद्ब्रुवते परमेष्ठी वा एषः । यदोदनः परमामेवैनं श्रीयं गमयति[22] ॥

May rivers flow and clouds give rain, may medicinal plants flourish and may all trees bear fruit. May I be the benefactor of the food like rice and milk products. The food served on the plate is a gift from nature, whose consumption will lead to the highest level of prosperity and well-being.

This mantra reminds us of the importance of a clean environment, the role of nature and people (farmers) who produce the food. It links the process of food production with the act of creation by nature's order; it is the nature's order which maintains the water cycle, the plants, and the farmers who produce food. By mentioning rice and milk it reminds us the wholesomeness of food.

आपः पुनन्तु पृथिवीं पृथिवी पूता पुनातु माम्। ब्रह्मणस्पतिर्ब्रह्मपूता पुनातु माम् । यदुच्छिष्टमभिज्यं यद्वा दुश्चरितं मम सर्वं पुनन्तु मामापोऽसतां च प्रतिग्रहं स्वाहा[23]॥

Let the water (made sacred by this Mantra) purify earth. Let such purified earth purify me. Let this water purify my teacher. Let the Vedas that were taught by the purified teacher cleanse me. Let this water help me regain purity that I might have lost by eating leftover and other such impure food. Let the water wash off all impurities that I might have accumulated due to my misdeeds. Let the water cleanse me from the mistake of accepting money

[22] Taittiriya Brahmana 2.7.16.4

[23] Mahānārāyaṇopaniṣad 23rd Anuvāka

from people who might not have earned it in righteous way. To attain the above boons I offer this water to self as oblation[24].

2.6.3 Araṇyāni sūkta (Goddess of Forest and Nature)

In this Araṇyāni sūkta[25] the forest is personified as a goddess and worshiped. The glory of forest and her role in the grand scheme of the natural order are poetically described in detail in this Ṛgvedic sūkta.

अरण्या॒न्यरण्यान्यसौ या प्रेव नश्यसि ।
कथा ग्रामं न पृच्छसि न त्वा भीरिव विन्दती ॥

She walks among her offspring the plants… From her and from her sprang the blossom of a flower and comes the tree.

वृक्षारवाय वदते यदुपावति चिच्चिकः ।
आघाटिभिरिव धावयन्नरण्यानिर्महीयते ॥

She walks to make the land fertile… The spring blossoms from her step, creates beauty… She dwells here and everywhere, her offspring are everywhere… She is both real and empirical... she is an illusion.

उत गाव इवादन्त्युत वेश्मेव दृश्यते ।
उतो अरण्यानिः सायं शक॒टीरिव सर्जति ॥

The divine forest goddess spreads her wings and fills the forest… enriches us like cow... You can feel her presence everywhere.

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[24] This mantra is used in the *mādhyānhika* (mid-day) ritual. After uttering this one has to sip the water from one's palm for self purification.

[25] Ṛgveda, अरण्यानिसूक्तम् 10.146.1-6

गामङ्गैष आह्वयति दार्वङ्गैषो अपावधीत् । वसन्नरण्यान्यां सायमक्रुक्षदिति मन्यते ॥

You can witness all, yet only a few can see her… Rare those who can merge with her… She moves and shifts and all her forms are pure… She is invisible and resides in her offspring.

न वा अरण्यानिर्हन्त्यन्यश्चेन्नाभिगच्छति ।
स्वादोः फलस्य जग्ध्वाय यथाकामं निपद्यते ॥

Those who kill her children, suffer accordingly… She treats all the simple minded and scholars alike… Earthlings come here for silence... She is a fragment of imagination... She is frightening for some and knowledge for others... She is fragrant and from her comes all medicine.

आञ्जनगन्धि सुरभिं बह्वन्नामकृषीवलाम् ।
प्राहं मृगाणां मातरमरण्यानिमशंसिषम् ॥

From her comes food and fruit without cultivation… She walks, she disappears, yet her aura surrounds me… She the mother doesn't hurt... I'm inside her womb... protected.

2.6.4 Comparison of Human and a Plant

The Bṛhadāraṇyakopaniṣad[26] compares the human being with a plant: in This outlines the comparison of the form of a human being is similar to that of a plant – in terms of being a life-form

यथा वृक्षो वनस्पतिः तथैव पुरुषोऽमृषा ।
तस्य लोमानि पर्णानि त्वक् अस्य उत्पाटिका बहिः ॥ १ ॥

[26] Bṛhadāraṇyakopaniṣad 3.9.28

A man is indeed like a mighty plant; his hairs are its leaves and his skin is its outer bark.

त्वचसः एव अस्य रुधिरम् प्रस्यन्दि त्वचस् उत्पटः ।
तस्माद् तद् अतुन्नाद् अतृण्णाद् प्रैति रसः वृक्षाद् इव आहतात् ॥२॥

The blood flows (from the skin) of the man, so does the sap (from the skin) of the plant. Thus blood flows from a wounded man in the same manner as the sap from a plant when it is chopped.

मांसानि अस्य शकराणि किनाटं स्नाव तत्स्थिरम् ।
अस्थीनि अन्तरतः दारुणि मज्जा मज्जोपमा कृता ॥३॥

Flesh within corresponds to the inner bark; the nerves are as tough as the inner fibers of the plant; the bones lie behind the flesh as the wood lies behind the soft tissue. The marrow of the human bone resembles the pith of the plant.

2.6.5 Agricultural fields

यस्यां वृक्षा वानस्पत्या ध्रुवास्तिष्ठन्ति विश्वह ।
पृथिवीं विश्वधायसं धृतामछावदामसि[27] ॥

In which place the plants and trees are steadily growing and sustaining the world, protecting and nurturing life and that land we worship.

2.6.6 Manuring

सञ्जग्माना अविभ्युषीरस्मिन् गोष्ठे करीषिणीः । बिभ्रतीः सोम्यं मध्वमनमीवा उपेतन ॥ इहैव गावः एतनेहो शकेव पुष्यत । इहैवोत प्र जायध्वं मयि संज्ञानमस्तु वः[28] ॥

[27] Atharvaveda 12.1.27

[28] Atharvaveda 3.14.3-4

Oh, karīṣiṇī (cow dung)! having come together with the soil for enriching the plants, rich in manure, bearing the sweet of Soma, come to this soil, free from disease.

2.6.7 Ecological protection

वनानि न प्रजहितानि[29] ॥

Forests should not be destroyed.

शिवो भव प्रजाभ्यः मानुषीभ्यस्त्वम् अङ्गिरः ।

मा द्यावापृथिवी अभिशोचीः मा अन्तरिक्षं मा वनस्पतीन्[30] ॥

Let the earth, heaven, plants and beings be happy. Don't destroy these in any manner.

2.6.8 Sun light and Rainbow

सप्त त्वा हरितो रथे वहन्ति देव सूर्य । शोचिष्केशं विचक्षण ॥

अयुक्त सप्त शुन्ध्युवः सूरो रथस्य नप्त्यः । ताभिर्याति स्वयुक्तिभिः[31] ॥

Hey Suryadeva, you're the protector of plants through your 7 colored (horse) chariot. In the sky, your rays have the power to both nurture and destroy everything.

2.6.9 Water, Air and plants

त्रीणि छन्दांसि कवयो वि येतिरे पुरुरूपं दर्शतं विश्वचक्षणम् ।

आपो वाता ओषधयः तानि एकस्मिन् भुवन आर्पितानि[32] ॥1

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[29] Ṛgveda 8.1.13

[30] Śukla-Yajurveda 11.45

[31] Ṛgveda 1.40.8-9

[32] Atharvaveda 8.1.17

Scholars refer to three elements of life on earth; they are water, air and plants. They exist in the world from the very beginning. They are called as 'candas' due to their nature of covering the earth and present everywhere.

2.6.10 Avi - The Chlorophyll in Plants

अविर्वै नाम देवता ऋतेनास्ते–परीवृता ।
तस्या रुपेण इमे वृक्षा हरिता हरितस्रजः[33] ॥

The word '*avi*' (M) means protector, as per Amarakosha and Halayudhakosha. According to Vedic pundits, this term in Atharvaveda refers to the green pigment or the 'Chlorophyll' (the essence) of plants, that which is present there due to '*ṛta*' (the universal cyclical order /nature's cycle) which surrounds everything and binds everything (10.8.31). Due to this reason it is considered as the protector of all life-forms.

2.6.11 Pollution

शिवो भव प्रजाभ्यः मानुषीभ्यस्त्वम् अङ्गिरः ।
मा द्यावापृथिवी अभिशोचीः मा अन्तरिक्षं मा वनस्पतीन्[34] ॥

Let the human beings and all life-forms be auspicious, Let the earth, heaven, plants and beings be pure. Don't destroy /pollute these in any manner.

2.6.12 Ṛta sūktam – Nature's cycle

मधु वाता ऋतायते मधु क्षरन्ति सिन्धवः ।माध्वीः नः सन्तु ओषधीः[35] ॥

[33] अथर्ववेद १०.८.३१

[34] śukla yajurveda 11.45

May the sweet winds bring order. The rivers bring sweet water. Sweet plants be there for us.

मधु नक्तमुतोषसो मधुमत्पार्थिवं रजः ।
मधु द्यौरस्तु नः पिता ॥

May the sweet night enrich the plants, May the sweet earth give prosperity. May the Sky our father be sweet to us

मधुमान्नो वनस्पतिः मधुमा अस्तु सूर्यः ।
माध्वीः गावो भवन्तु नः ॥

May the plants be sweet to us, may the Sun god be sweet to us, may there be sweet cows for us.

2.7 List of various Agriculture hymns in The Vedas

The Vedas being the store-house of great wisdom of ancient lore, contains many hymns on Agriculture. Some of the important hymns relating to agriculture are given in the Table No. 2.1. including certain select hymns and verses are highlighted to signify the importance of agriculture in Vedas.

Ṛg-veda	Vedic hymn (सूक्तम्)	Description
2.1	*अन्न-सूक्तम्* (*anna-sūkta*)	Worship of food, plants and their role in sustaining life on Earth
4.57.1 - 8	*क्षेत्रपति-सूक्तम्* (*kṣetrapati-sūkta*)	Worship of the lord of Agriculture fields and also contains various duties of farmers

[35] Ṛg veda 1.9.6 - 8

5.83.1 - 10	*पर्जन्य-सूक्तम्* (*parjanya-sūkta*)	Chants for bounty of rains and abundance of water for agriculture
5.84.1 - 3	*पृथ्वी-सूक्तम्* (*pṛthvī-sūkta*)	Earth as the fundamental basis of life and praise of its life sustaining abilities
6.28.1 - 8	गो-सूक्तम् (*go-sūkta)*	Worship of Cows, animal husbandry and their role in agriculture and human life
7.47.1 - 4 7.48.1 - 4 7.49.1 - 4 7.50.1 - 4	आपस्सूक्तम् (*āpas-sūkta*)	Water and its role in ecology and the universal order in sustaining of life
10.75.1 - 9	नदी-सूक्तम् (*nadī-sūkta*)	Worship of Rivers as goddesses and their usage for irrigation in agriculture
10.97.1 - 23	ओषधि-सूक्तम् (*oṣadhi-sūkta*)	Worship and praise of Medicinal Plants as the mother of life on earth
10.146.1 - 6	अरण्यानि-सूक्तम् (*araṇyāni-sūkta*)	Worship of '*araṇyāni*' – Forest, Personified Goddess and her role in maintenance of Life on earth, balance of the ecological system

Table 2.1 Agricultural hymns in Ṛg-veda

Atharva-Veda	सूक्तम् (Vedic hymn)	Description
1.4.1 - 4 1.5.1 - 4	आप-प्रशंसा (*āpa praśaṃsā*)	Worship, praise and prayers to the Waters, and Rivers

Atharva-Veda	सूक्तम् (Vedic hymn)	Description
1.6.1 - 4 1.33.1 - 4 3.13.1 - 7 6.23, 6.24 19.2.1 - 5		
3.17.1 - 9 3.24.1 - 7	कृषि-सूक्तम् (*kṛṣi-sūkta*)	Glorification on various aspects of agriculture. Praise on the harvest and produce
3.18	वनस्पति-सूक्तम् (*Vanaspati-sūkta*)	Glorification and worship of Plants, trees and forests
4.15.1 - 16 7.18.1 - 2	वृष्टि-सूक्तम् (*vṛṣṭi-sūkta*)	Rains and their role in agriculture and food. Worship of the rains
4.34.1 - 8 4.35.1 - 7 11.1	अन्नसमृद्धि-सूक्तम् (*anna-samṛddhi-sūkta*)	Prayers for abundance of food production and availability for the betterment of humanity and all life forms
4.37	कृमिसूक्तम् (*kṛmi-sūkta*)	Pest control methods using medicinal herbs
6.16.1 - 4 8.7.1 – 6	ओषधीनां प्रशंसा (*oṣadhīnāṃ praśaṃsā*)	Praise of various plants, Worship of the medicinal plants
6.68.1 - 3	वपनसूक्तम् (*vapana-sūkta*)	Praise of agriculture - planting and sowing of seeds and plants
6.17, 7.58, 6.142.1 - 3	अन्न-सूक्तम् (*anna-sūkta*)	Praise of foods (grains) and other produce as the basis of sustaining

Atharva-Veda	सूक्तम् (Vedic hymn)	Description
		life
11.1 11.3	ओदन-सूक्तम् (*odana-sūkta*)	Rice as the foundation of human food and life
12.1.1 - 63	पृथ्वी-सूक्तम् (*pṛthvī-sūkta*	Prayer, worship and praise of Mother Earth
6.141 10.10.1 - 34 12.4.1 - 53	गो-महिमा (*go-mahimā*	Worship and animal husbandry

Table No. 2.1 Agricultural hymns in Atharva Veda

2.8 Rāmāyaṇa - Plant diversity in Rāmāyaṇa

Rāmāyaṇa is the first '*itihāsa*' (Epic) and narrates the life journey of Sri. Rāma, one of the most important King in the *'sūrva-vaṃsa'* (Surya clan). Throughout his physical journey, Sri. Rāma was crossing many places including larges forests across Ancient India. The narrator of the epic Sri. Vālmīki has described many of these forests in detail along with descriptions of many plants within those forests. The plants described include evergreen /deciduous trees, flowers, medicinal, edible plants, climbers, etc.

The main forests described are Citrakūṭa-vana, Daṇḍaka-araṇya, Pañcavaṭī-vana, Kiṣkindha, Lanka and also the forests beyond Himalayan mountains. Details of the forests include in addition to flora and fauna, the water elements, animals and birds, etc. There are also passages which describe the land surface, biodiversity, vegetation, density, degrees of wilderness, etc. The two major forest types according to Rāmāyaṇa are large

forest and small forest. **Citrakūṭa-vana and Daṇḍaka-araṇya were mentioned as '*mahāraṇya*'** (big forest) and rest of others were small forests at that time.

2.8.1 Citrakūṭa-vana

प्रहृष्टकोयष्टिककोकिलस्वनैर्विनादितं तं वसुधाधरं शिवम् ।
मृगैश्च मत्तैर्बहुभिश्च कुञ्जरैः सुरम्यमासाद्य समावसाश्रमम्[36] ॥

The auspicious mountain (Citrakūṭa) resounds with the note of cheerful lapwings and cuckoos. Intoxicated elephants and deer move about in the enchanting mountain. In this place you can settle in a hermitage.

समासाद्य तु तं वृक्षं वसेद्वातिक्रमेत वा ।
क्रोशमात्रं ततो गत्वा नीलं द्रक्ष्यथ काननम्[37] ॥
पलाशबदरीमिश्रं रम्यं वंशैश्च यामुनैः ।
स पन्थाश्चित्रकूटस्य गत स्सुबहुशो मया[38] ॥

Reaching that tree, you may tarry or proceed further. A krosa from there, you will see a beautiful forest filled with dark trees mixed with Palasas and badaris and bamboos on the Yamuna. That path leads to Citrakūṭa. I had traveled through it several times.

तस्मिन्बिल्वाः कपित्थाश्च पनसा बीजपूरकाः।
आमलक्यो बभूवुश्च चूताश्च फलभूषणाः[39] ॥

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[36] Vālmīki Rāmāyaṇa 2.54.43

[37] Vālmīki Rāmāyaṇa 2.55.8

[38] Vālmīki Rāmāyaṇa 2.55.9

[39] Vālmīki Rāmāyaṇa 2.91.30

There the best of fruit-bearing trees like bilva trees, kapittha trees, citrons, āmalaki trees and mango trees full of fruits sprang up here (in Citrakūṭa).

2.8.2 Daṇḍaka-araṇya

सालैस्तालैस्तमालैश्च खर्जूरपनसाम्रकैः । नीवारैस्तिमिशैश्चैव पुन्नागैश्चोपशोभिताः[40] ॥

चूतैरशोकैस्तिलकैश्चम्पकैः केतकैरपि । पुष्पगुल्मलतोपेतैस्तैस्तैस्तरुभिरावृताः[41] ॥

चन्दनैस्पन्दनैर्नीपैः पर्णासैर्लिकुचैरपि । धवाश्वकर्णखदिरैः शमीकिंशुकपाटलैः[42] ॥

This place is covered with trees of sal, palmyrah, mango, jackfruit, dates, kadamba, punnāga, aśoka, campaka, tilaka, ketaka, sandalwood, spandan, dhavā, aśvakarna, parṇāsa, khadira, śami, kimśuka and pātala. It (daṇḍaka-araṇya) is full of other trees, small trees, shrubs, wild paddy, flowering bushes and creepers that run on the ground.

A total of 182 plant species were mentioned in Vālmīki Rāmāyaṇa at various places among the 5 forests. Among these 182 plant species, 105 are trees, 5 are small trees, 8 are shrubs, 22 are herbs, 15 are climbers, 6 are grasses and 20 are aquatic herbs[43].

2.9 Agriculture, Botany and Ecology in Mahābhārata

Mahābhārata is the second oldest and longest '*itihāsa*' (Epic-history) and narrates the life journey, valor and achievements of the '*candra-vaṃsa*' (Chandra clan) kings and Srī. Kṛṣṇa. Narrated by Sage Vyāsa in Sanskrit, this epic is spread in 18 books. In Mahābhārata, 17 books out of the

[40] Vālmīki Rāmāyaṇa 3.15.16

[41] Vālmīki Rāmāyaṇa 3.15.17

[42] Vālmīki Rāmāyaṇa 3.15.18

[43] M. Amirthalingam and P. Sudhakar, Plant & Animal Diversity in Valmiki's Ramayana, C.P.R. Environmental Education Centre, Chennai, India

total 18 books describe the life history and exploits of the Kuru clan cousins – the Pāṇḍava's and the Kaurava's. The war among these cousins and their respective allies was also described in detail. Post war there are several passages which describe in detail of the duties of Kings with respect to civic administration and its intrinsic parts such as ecology, nature preservation, agriculture, administration, commerce, etc. Mahābhārata is considered as the fifth Veda due to its detailed coverage and advice on worldly affairs, human development and also spiritual emancipation.

सर्वकामफलाः वृक्षाः [44]।

Plants fulfill all desires (of humankind).

2.9.1 Forests are sacred wealth

Forest offers food and shelter for all animals – Forests maintains the '*Ṛtu'* (seasons) bring rain and maintains the weather. Forests are considered sacred wealth of a nation and every king in the olden days knew their significance[45].

मा वनं छिन्धि स व्याघ्रं मा व्याघ्रान्नीनशो वनात् ।
न स्याद् वनं ऋते व्याघ्रान्व्याघ्रा न स्युः ऋते वनात् ॥
वनं हि रक्ष्यते व्याघ्रैर्व्याघ्रान् रक्षति काननम्[46] ॥

Don't destroy the forests and tigers and don't make forest devoid of tigers. Forests can't be saved without tigers and tigers can't live without forests, because forests protect tigers and tigers protect the forests.

[44] Mahābhārata ādiparvan

[45] Mahābhārata, Śāntiparvan

[46] Mahābhārata Udyogaparva 6.37.41 & 42

2.9.2 Science of Photosynthesis

तेन तज्जलमादत्तं जरयत्यग्निमारुतौ ।

आहारपरिणामाच्च स्नेहो वृद्धिश्च जायते[47] ॥

Water is drawn by the roots, it reacts with heat from sunlight and air (CO2) and using the combinations of water, air and sunlight, it transforms it into Sap, from which growth happens.

2.9.3 Botany

The knowledge of Osmosis in Mahabharata was later discovered by Kramer - 1969 AD which states – *Due to rapid evaporation of water from leaves during transpiration, a tense is created and transmitted to the xylem (through a semi-permeable membrane) of the roots, causing the water to cross cell wall and rise upwards*[48].

2.9.4 Plants and mankind

Growing more plants have been prescribed in Mahabharata for the greater good and protection of mankind and life on Earth.

मानवं पुत्रवद् वृक्षाः तारयन्ति परत्र च ।

पुत्रवत्परिपाल्यास्ते पुत्रास्ते धर्मतः स्मृताः[49] ॥

2.9.5 Plants are sentient beings

Sensory intelligence of plants is discussed in detail during the (Bhṛgu-Bharadvāja samvāda) discussions between the teacher Sage Bhṛgu and the student Sage Bharadvāja in the Mokṣadharma-parva of Śānti-parva, in the epic Mahābhārata. The details of the discussions are given below.

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[47] Mahābhārata Śānti-parva 12.182.18

[48] Mahābhārata Śānti-parva 12.186.13 – 16

[49] Mahābhārata Anuśāsana-parva 5.8.30

- **Body**

शरीरं पाञ्चभौतिकम् । इत्येतैः पञ्चभिर्भूतैर्युक्तं स्थावरजङ्गमम् ।
श्रोत्रं घ्राणं रमः स्पर्शो दृष्टिश्चेन्द्रियसंज्ञिताः[50] ॥

Body is made up of 5 primordial elements. The sensory organs such as auditory, olfactory, gustatory, integumentary and vision are known as 'indriya' and is common for all living beings movable and immovable alike.

- **Ethereal**

घनानामपि वृक्षाणामाकाशोऽस्ति न संशयः ।
तेषां पुष्पफलव्यक्तिर्नित्यं समुपपद्यते[51] ॥

The plants produce bear flowers, fruits, etc. because of their ethereal nature they are able to bear these.

- **Integumentary sense**

ऊष्मतो म्लायते वर्णं त्वक्फलं पुष्पमेव च ।
म्लायते शीर्यते चापि स्पर्शस्तेनात्र विद्यते[52] ॥

Leaves, flowers, fruits and skin undergo shrinking, drying and fading when there is excess heat or cold, this shows that plants have the sense of touch.

[50] Mahābhārata Śānti-parva 12.182.5

[51] Mahābhārata Śānti-parva 12.182.10

[52] Mahābhārata Śānti-parva 12.182.11

- Auditory sense

वाय्वग्न्यशनिनिष्पेषैः फलं पुष्पं विशीर्यते ।
श्रोत्रेण गृह्यते शब्दस्तस्माच्छृण्वन्ति पादपाः[53] ॥

Flowers and fruits fall down due to the sound, wind, fire and lightening and therefore plants have the sense of auditory.

- Visual sense

वल्ली वेष्टयते वृक्षं सर्वतश्चैव गच्छति ।
न ह्यदृष्टेश्च मार्गोऽस्ति तस्मात्पश्यन्ति पादपाः[54] ॥

Plants like climbers and creepers grows in all directions (in search of sun), if they can't see how they can climb/creep. This proves that the plants have the sense of vision.

- Olfactory sense

पुण्यापुण्यैस्तथा गन्धैर्धूपैश्च विविधैरपि ।
अरोगाः पुष्पिताः सन्ति तस्माज्जिघ्रन्ति पादपाः[55] ॥

The plants are sensitive to smell, they can identify good and bad. They respond to different types of smoke (such as polluting or fumigation) and thus plants have sense of smell.

- Gustatory sense

पादैः सलिलपानाच्च व्याधीनां चापि दर्शनात् ।
व्याधिप्रतिक्रियत्वाच्च विद्यते रसनं द्रुमे[56] ॥

[53] Mahābhārata Śānti-parva 12.182.12

[54] Mahābhārata Śānti-parva 12.182.13

[55] Mahābhārata Śānti-parva 12.182.14

[56] Mahābhārata Śānti-parva 12.182.15

Water absorbed through the roots of the plants can cause diseases due to the taste, and if the water is good then it can promote growth. This proves that the plants have the sense of taste.

सुखदुःखयोश्च ग्रहणाच्छिन्नस्य च विरोहणात् ।
जीवं पश्यामि वृक्षाणामचैतन्यं न विद्यते[57] ॥

Plants grow back when they are cut and they also suffer a lot of physical pain like all animals, therefore they are living beings like all others.

This in late 19th century for first time proved using modern scientific methods by Dr. Jagdish Chandra Bose. Dr. Bose during his experiments proved the reactions of plants to sensory stimuli, which he demonstrated to scientists in the year 1901.

2.9.6 Importance of Agriculture

The importance of (1) agriculture as primary Economic driver and (2) agricultural studies as a core part of education as discussed in Mahābhārata are given below. In addition, in many places, Mahābhārata also critically instructs the role of agriculture in nation building, polity and administration.

कच्चिद्राष्ट्रे तडागानि पूर्णानि च महान्ति च ।
भागशो विनिविष्टानि न कृषिः देवमातृका[58] ॥

In which ever country where the lakes are built and which are full and also distributed (for irrigation), in those countries agriculture is not dependent on monsoons. This verse is an advice to the king to build water-bodies in the country.

[57] Mahābhārata Śānti-parva 12.182.17

[58] Mahābhārata Sabhā-parva 2.20.5.0.67

The king should protect agriculture, trade and commerce for the benefit people and upholding of loka dharma[59].

2.10 Summary

This chapter highlights the Vedas literary focus on agriculture along with certain key Vedic passages relating to cultivation, ploughing, pest control, Goddess of forests and Ecology and prayers to the lord of agriculture for good yields. In addition, certain key passages are also given from Ramayana and Mahabharata specific to agriculture and botany. These are highlighted to delve deeper to understand the importance for agriculture since ancient days and also to understand the higher principles of sustainability.

[59] Mahābhārata Bhīṣma-parva 7.12.63.10

Chapter 3: *Vṛkṣāyurveda*, a detailed overview

3.1 Background

Vṛkṣāyurveda is a holistic plant life science discipline concerned primarily with Agriculture, Agroforestry and Botany including all the allied disciplines such as soil science, seed management, irrigation, pest control, agro-meteorology, post-harvest storage, and ecology. As many of these sciences are tightly interconnected with respect to their impact in Agriculture and human livelihood, all these branches of sciences were offered as part of the integrated educational discipline called *Vṛkṣāyurveda*, and thus this becomes a holistic science. On par with Ayurveda, *Vṛkṣāyurveda* was considered to be an important scientific discipline for the benefit of one and all in ancient India.

The most important ancient administrative and economic treatise of India '*Arthaśāstra'* defines *Vṛkṣāyurveda* as 'वृक्षादि-प्रसव-आरोप-पालनादि-कृति-विद्या ' meaning *the education of the science of Plants from germination, cultivation, maintenance, and to all allied activities.* It is to be noted that this definition includes most of the agriculture activities during Sri. *Kautilya's time)* and later, the *Vṛkṣāyurveda* texts *'Kṛṣiśāsana'* and *'Vṛkṣāyurveda of Surapāla'* define it as *'उपवन-दकार्गल-विज्ञान-तरु-रोपण-चिकित्सा-विधिः'* meaning *the rules of Agroforestry, Water management, Plant growth & treatment.* Kāmasūtra of Vātsyāyana defines it as 'वृक्षायुर्वेदयोगः इति वृक्षादि -रोपण-पुष्टि-चिकित्सा-वैचित्र्य-कृतिः' - *activities of cultivation of plants, growth, treatment and garden design is Vṛkṣāyurveda yoga*. Therefore, *Vṛkṣāyurveda* deals with end-to-end cycles of agriculture.

Vṛkṣāyurveda in essence is the continuation of Vedic ideas (*Ṛg Veda* and *Atharva Veda*) with respect to the entire gamut of Agriculture and allied sciences. As per archaeologists, agriculture and animal husbandry have been practiced in India for over 8000 years and the practical knowledge being handed over from generation to generation and have been scientifically codified in *Vṛkṣāyurveda* texts specifically for different regions, land types, rain patterns, soil conditions, water availability, and topographic /seasonal conditions.

Vṛkṣāyurveda is considered to be originated from *Atharva veda* and at the same time shares philosophy, ontology, and treatment principles with Ayurveda which originated from Ṛgveda. According to the Asian Agri-History Foundation (AAHF), *Vṛkṣāyurveda* as a science has been in practice in India for over 3000 years.

Currently, about 15 *Vṛkṣāyurveda* texts in Sanskrit and other languages have been published starting with '*Kṛṣi parāśara'* (~B.C.E 400 by AAHF) to the most recent text of '*Kṛṣi śāsana'* in 19th Century C.E. *Vṛkṣāyurveda* texts are written in ancient and medieval times and were generally in Sanskrit language baring a few in local language such as in Bengali, Kannada, Telugu, etc. and these were written after 16th Century C.E.

Vedas, being time-immemorial—is an ocean of traditional scientific knowledge and wisdom. The Vedic literature is vast and has guidance for every walk of human life – psychologically and socially. Vedas are the best sources of comprehensive ancient human wisdom which stood the test of time and scientific scrutiny. With respect to many scientific disciplines civic development, Seers of Vedic lore have contributed immensely and recorded

them for the continuation of the Vedic tradition and for the betterment of humanity.

3.2 '*Anubandha-catuṣṭaya*' of *Vṛkṣāyurveda*

'Anubandha-catuṣṭaya' denotes the four important prerequisites for the critical study of any particular *śāstra* text in the ocean of Sanskrit literary works. *'anubandha-catuṣṭayo nāma adhikāri-viṣaya-sambandha-prayojana'*, meaning capacity, subject matter, relationship (between the subject and the person) and the result. It is to be understood that, most of the *śāstra* texts have mokṣa (spiritual emancipation) as the ultimate goal.

The ancient dictum of śāstra defines it as *'sarvo'pi śāstrārthaḥ puruṣārtha paryavasāyī'* meaning, 'the essence of all 'śāstra' is the culmination into the ultimate purpose of life, which indeed is the liberation (from the mundane worldly cycles). *Vṛkṣāyurveda* being an important science as part of *vārtā* (economic activity) also culminates into fulfilling all the four aspects of *puruṣārtha* (the purpose of life) such as *dharma* (order /right conduct), *artha* (materialistic means), *kāma*' (desire-fulfillment), *mokṣa* (liberation).

In the most important Ayurvedic canon, '*carakasaṃhitā',* it is clearly propounded that health is paramount not just for a good worldly life but also for spiritual emancipation and diseases are indeed hindrances to achieving these life goals.

Food sustains life and health and thus is the means for all things meaningful. All beings sustain based on food60. Food depends on crop and

60 अन्नं प्राणा बलं चान्नमन्नं सर्वार्थसाधनम् ।

crop depends on agriculture, therefore first and foremost, one should focus on agriculture[61]. An agriculturalist should know seeds, soil fertility, planting, growth, yield, measurements, trade, etc. completely[62]. Leave everything else and take care of plants as they are the ones which are instruments for worldly life, means, desire-fulfillment and spiritual emancipation[63]. Human health is entirely dependent on food. And the puruṣārthas*[64]* are dependent on health, in turn. Therefore, discussing about the science, *Vṛkṣāyurveda,* that promotes health is apt and necessary.

3.3 *Vārtā* – Economics in Ancient India

In Ancient India, Vedas and other *śāstra* (holistic scientific disciplines) including agriculture are collectively were considered to be part of *vidyā* meaning education and also as *vidyāsthānāni* meaning branches /disciplines of formal knowledge /education)

देवासुरमनुष्याश्च सर्वे चान्नोपजीविनः ॥

61 अन्नं हि धान्यसंजातं धान्यं कृष्या विना च ।

तस्मात् सर्वं परित्यज्य कृषिं यत्नेन कारयेत ॥ - 1.6-7, *kṛṣiparāśara*

62 बीजानामुप्तिविच्च स्यात्क्षेत्रदोषगुणस्य च ।

मानयोगञ्च जानीयात् तुलायोगांश्व सर्वशः ॥ - *6.330, Manusmṛti*

63 एतत्सत्यं परिज्ञाय वृक्षारोपणं समारभेत् ।

धर्मार्थकाममोक्षाणां द्रुमेभ्यः साधनं यतः ॥ - *1.8, surapāla-vṛkṣāyurveda*

64 धर्मार्थकाममोक्षाणाम् आरोग्यं मूलमुत्तमम् ।

रोगास्तस्य अपहर्तारः श्रेयसो जीवितस्य च ॥ - *1.14, sūtrasthāna, carakasaṃhitā*

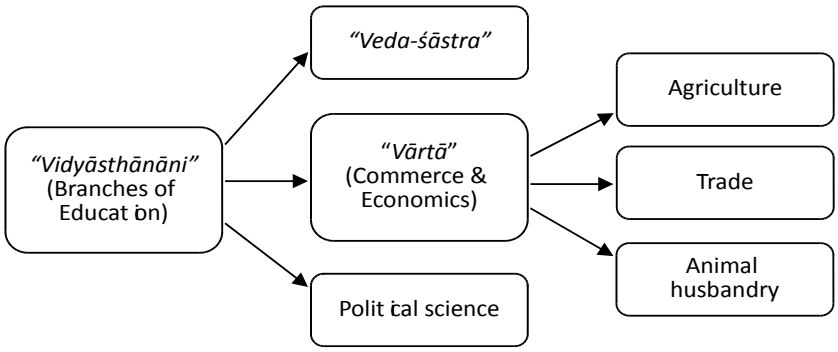

Figure No. 3.1 Vidyāsthānāni

Veda (Vedic sciences), Political science and Economics (Agriculture, Trade, Animal husbandry and Lending) are the three main branches of education. Based on these educational principles, the journey of life on earth is managed65.

Strengthening trade, tax, markets and likewise agriculture and through such economic activities, all-round management and protection is done by these scholars66. Agriculture, animal husbandry and trade here are the sustaining factors of human life. The education also includes Polity and Veda-śāstra, by these human beings live in this world67.

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65 त्रयी वार्ता दण्डनीतिस्तिस्रो विद्या विजानताम् ।

ताभिः सम्यक् प्रयुक्ताभिः लोकयात्रा विधीयते ॥ - 3.33.149.0.31, Mahābhārata, (Book – III, Vanaparva)

66 पण्याकरवणिज्याभिः कृष्याथो योनिपोषणैः ।

वार्तया धार्यते सर्वं धर्मैः एतैः द्विजातिभिः ॥ 3.33.149.0.30, *Mahābhārata, (Book – III, Vanaparva)*

67 कृषिगोरक्ष्यवाणिज्यम् इह लोकस्य जीवनम् ।

दण्डनीतिः त्रयी विद्या तेन लोकाः भवन्त्युत ॥ 3.37.198.0.23, *Mahābhārata,*

Philosophy, Veda-śāstra, Political sciences and Economics (Agriculture, Trade, Animal husbandry and Lending) and Polity are the four branches of education68 Agriculture, Animal husbandry and Trade are Economics (‘*Vārtā*’)69. Agriculture, Trade, Animal husbandry and Lending (banking) are four types of (‘*Vārtā*’) Economic activities70.

Similar views about the importance of the primary economic activities such as agriculture, animal husbandry, trade and lending are found in many ancient Sanskrit economic and administration treatises such as *Arthaśāstra*, *Sukranīti*, *Nītisāra* of *Kāmandaka*, *Mānasollāsa* and also in *Rājadharmānuśāsana-parva*’ (duties of Kings and rulers) of *śānti-parva* in Mahābhārata.

Therefore, based on above references, it is proven beyond doubt that Agriculture was the primary driver of economics in ancient India. The scientific pursuit of agricultural studies as a separate important branch is evident due to agriculture being termed as a *vidyā*, (education) in ancient India.

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68 आन्वीक्षिकी त्रयी वार्ता दण्डनीतिश्च इति विद्याः । *Arthaśāstra, Book 1, Chapter 2*

69 कृषिपशुपाल्ये वाणिज्या च वार्ता ॥ *Arthaśāstra*, Book 1, Chapter 4

70 कृषिर्वाणिज्यगोरक्षा कुसीदं तुर्यमुच्यते (इति) वर्ता चतुर्विधा । *Bhāgavata purāṇam* – 10.24.21

3.4 *Vṛkṣāyurveda* and Ayurveda

The supplementary sections of Vedas are known as '*upaveda*' and they cover various aspects of human lives including Economics, Arts, Medicine, etc. Though these supplementary disciplines have been covered briefly as part of Vedas, they were expounded in *upaveda*. These upaveda are also part of the holistic scientific disciplines post Vedic period as a follow-up for Vedas.

Vṛkṣāyurveda as part of Commerce & Economics (*Vārtā*) on the one hand and also as a sister-science of Medical sciences (Ayurveda) on the other hand. Therefore, it is one of the most important part of basic scientific studies in Ancient India as confirmed by *Arthaśāstra*.

Following are the *Upavedas*[71]:

- Ayurveda ('*āyus*' - Medicine and Life sciences), is the upaveda of Ṛgveda
- Dhanurveda ('*dhanus*' - Sports and Archery), is the upaveda of Yajurveda
- Gāndharvaveda ('*nātya*' - Arts and Music), is the upaveda of Sāmaveda
- Arthaśāstra ('*Vārtā*' - Economics & '*daṇḍanīti*' - Polity /administration), is the upaveda of Atharvaveda

Vṛkṣāyurveda being an integral part of Ayurveda, deals with *pāñcabhautika-prakṛti* (Five primordial elemental nature) culminating into the ensuring the livelihood by the production of '*āhāra*' (diet) and '*auṣadha*' (medicines) and thus covers the end-to-end cycle of harmonious living with nature.

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71 आयुर्वेदो धनुर्वेदो गान्धर्वश्चैव ते त्रयः।
अर्थशास्त्रं चतुर्थं तु विद्या ह्यष्टादशैव ताः ॥ V.P. 3. 6. 28

Vṛkṣāyurveda in verbatim follows the Botanical classifications found in various Ayurvedic lexicon and materia-medica texts such as 'Rāja nighanṭu' 'Bhāvaprakāśa nighanṭu' and also confirms with all the plant /soil classifications found in vanauṣativarga and bhūmivarga of Amarakośa.

In addition, entire pharmacological principles of *Vṛkṣāyurveda* are also same as that of Ayurveda starting with the *pañca-bhūta siddhānta* to *rasapañcaka* (pharmaco-dynamics) and *dravya-guṇa vijñāna* (materia-medica) and then *doṣa-praśamana* (homeostasis) and *cikitsā* (treatment).

Considered as a continuation of agricultural parts of *Atharva veda*, *Vṛkṣāyurveda* deals with '*kṛṣitantra*' (agriculture – crop /food grains cultivation) and '*upavanakriyā'* (Agroforestry – all types of plant cultivation) and thus covers the end-to-end cycle of the major activity of economics.

Agricultural references with respect Medicinal plant cultivation and storage were covered in detail in the Ayurveda texts such as '*caraka*-saṃhitā' and '*suśruta*-saṃhitā' and also other '*dravya-guṇa vijñāna*' (pharmacology) texts. Therefore, it can be understood that many of these scientific disciplines are interconnected and are also supplementary of the Vedic texts. *Vṛkṣāyurveda* is also one among the 64 essential *kalā* or traditional *vidyā* (education) in Education in olden days.

3.5 *Vṛkṣāyurveda's* literature wealth

Several texts of *Vṛkṣāyurveda* have been published from India's rich source of manuscripts spread across Oriental Research Institutes, Universities and Private collections. Based on these published material, it is understood

that *Vṛkṣāyurveda* texts provided agricultural methods specific to various regions.

According to AAHF (Asian Agri-History Foundation), *Vṛkṣāyurveda* as a branch of science had several texts specific to regions, various soil types, different crop types, and topographical changes. However, with the promotion and government patronage for Persian language and texts during the Mogul rule of India and then to the English language and texts during the British rule of India, many 'geography specific' and 'crop specific' *Vṛkṣāyurveda* texts in Sanskrit language have been lost.

As on date, over 30 *Vṛkṣāyurveda* manuscripts are yet to be and published. In addition, from the 30+ published material, many of the unique agricultural techniques and methods are yet to be experimented by Agricultural scientists or practitioners.

Different *Vṛkṣāyurveda* texts focus on different topics and it is therefore essential to refer to many texts to get the overall picture, holistic understanding and also numerous methods, processes, technologies of the traditional agricultural practices of India. The table 3.1 in the section 3.6.1, provides the details of several *Vṛkṣāyurveda* treatises and their focus areas.

3.5.1 Published texts and manuscripts of *Vṛkṣāyurveda*

Out of the several published ancient Sanskrit texts in the last 130 years, the following table provides a list of over 20 texts, specifically *Vṛkṣāyurveda* and 20 other treatises which cover various aspects of *Vṛkṣāyurveda* in chronological order.

	Name	Author	Period	Description
1.	*Kṛṣi Parāśara*	Parāśara	~ 400 B.C.E	Agro Meteorology, Water management,
2.	*Kṛṣi sāmanya nirṇaya*		~ 350 B.C.E	Commentary on Kṛṣi Parāśara – with additional inputs on seasons specific to agriculture in Western coastal areas right from Maharashtra till Kerala
3.	*Śālihotra Vṛkṣāyurveda*	Śālihotra	~ 300 B.C.E	Compendium of Agriculture
4.	*Arthasāśtra*	Kautilya	~ 300 B.C.E	Agriculture management, economy and Commerce
5.	*Kūpādi-pratiṣṭhā, Vṛkṣa-ārāmādi-pratiṣṭhā, Vṛkṣa-āyur-jñāna* (Agni Purāṇam)	Vyāsa		Various agricultural (*Vṛkṣāyurveda*) methods including construction of water bodies, Agroforestry and plant disease treatment

6.	*Vṛkṣāyurveda varṇana, Druma-ropaṇa-nirūpaṇa,* (Vishṇudharmottara Purāṇam)	Vyāsa		Various agricultural (*Vṛkṣāyurveda*) methods
7.	*Vṛkṣotsava-vidhi, Vṛkṣa vimarśa, Vṛkṣavaikṛtya* (Mātsya Purāṇam)	Vyāsa		*Vṛkṣāyurveda* methods, Tree /Plant festivals
8.	*Go mahātṃya* (*Sṛṣṭi khāṇḍa,* Padma Purāṇam)	Vyāsa		Animal husbandry
9.	*Skānda-purāṇam (Aruṇācalamāhātmya)*	Vyāsa		Agroforestry
10.	*Vṛkṣāyurveda sūtra*	Dattila	~ 100 B.C.E	Referred in *Kuṭṭanimatam* of Dāmodara Gupta
11.	*Kṛṣi-saṅgraha*	Parāśara	~ 100 C.E	Various agricultural (*Vṛkṣāyurveda*) methods
12.	*Kṛṣi-tantra*	Kātyāyana	~ 100 C.E	Various agricultural (*Vṛkṣāyurveda*) methods
13.	*Parāśara-Vṛkṣāyurveda*	Parāśara	~ 150 C.E	Botany, Taxonomy,

				Morphology, etc.
14.	*Gulma Vṛkṣāyurveda*			Horticulture
15.	* *Kāmasūtra*	Vātsyāyana	~ 400 C.E	Parts on gardening, horticulture
16.	* *'Vṛkṣādivimarśa' (Ārāmādhipati)- Śukranīti*	Śukrāchārya	~ 400 C.E	Chapter on Agroforestry, Botany and Agricultural economics
17.	*Vanauṣadi varga, Vaiśya varga, Bhūmivarga* (Amarakośa)	Amara Simha	~ 400 C.E	Taxonomy and synonyms of over 320 plants, Synonyms, Agriculture, Land and soil classifications
18.	*Sasyajātaka, Kusumalatādhyāya, Vṛkṣāyurvedādhyāya, Udakārgalādhyāya* (Bṛhat Saṃhitā)	Varāha Mihira	~ 400 C.E	Four chapters dedicated to – Crops, Agroforestry, Gardening, and Water identification
19.	*Bhūgarbha-jala-jñāna-śāstram*	Varāha Mihira	~ 400 C.E	Geology and Ground water identification and management
20.	*Ādipurāṇam*	Jīneśvara	~ 400 C.E	Agroforestry, Medicinal plant cultivation, etc.

21.	*Gurusaṃhitā*		~ 500 C.E	Agro-meteorology, Rain patterns
22.	*Sumaṅgala vilāsinī*	Buddhagośa	~ 600 C.E	Contains a chapter on Agricultural and Botanical details of Plants
23.	*Kāshyapīya Kṛṣisūkti*	Kāshyapa	~ 600 C.E	Compendium of Rice and Annual crops including soil treatment
24.	*Abhidhāna-cintāmaṇi pariśiṣṭa – Nighanṭu śeṣa*	Hemacandra	~ 650 C.E	Botanical details and classifications of Medicinal plants and herbs
25.	*Vṛkṣa-āyurguṇa*		~ 800 C.E	Botanical, morphological data of over 350 herbs
26.	*Dhanvantarī nighanṭu - Bheṣajavidyā*		~ 800 C.E	Botanical and Identification details of Medicinal herbs
27.	*Surapāla-Vṛkṣāyurveda*	Surapāla	~ 1000 C.E	Collection and Cultivation and Bio-inputs for various crops. 'Kuṇapajala' is

				highlighted in this text.
28.	*Lokavijayayantram*			Agro-meteorology, Rain patterns
29.	*Bheṣaja-vidyāsūkti*			Medicinal plants and their characteristics including cultivation
30.	*Lokopakāra*	Chavundarya	~ 1025 C.E	In Kannada – agriculture specific to Central Karnataka region
31.	*Abhilaṣitārtha-cintāmaṇi (Mānasollāsa)*	Someṣvara deva	~ 1129 C.E	Horticulture, Agroforestry
32.	*Upavana Vinoda (Śārngadhara paddhati)*	Śārngadhara	~ 13th Cen. C.E	Agroforestry, Upavanam, Gardening, Arboriculture
33.	**Saddarśana samucchaya*	Jīnabadra sūri (Guṇaratna commentary)	~13th Cen. C.E	Botany, Plant anatomy, Plant pathology
34.	*Pṛthvī nirūpaṇam*	Udayanācārya		Botany and Morphology
35.	*Nyāyabindu tīkā*	Dharmottara		Agronomy, Botany

36.	*Śabdacandrikā*	Cakrapāṇidatta	~ 14th Cen. C.E	Lexicon of plants and Ayurveda substances. Contains 398 plant details with synonyms
37.	*Viśvavallabhā*	Chakrapāṇi Miśra	~ 1540 C.E	Upavanam, Agriculture, Seed management, Horticulture
38.	*Śivatattva ratnākara*	Basavabhūpāla (Popularly known as Basappa naik & Basavarājā)	1694 C.E	Encyclopedic work in Sanskrit with 30,000 verses – Few chapters on agriculture specific to Southern hilly region (Mysore - Vayanadu)
39.	*Kṛṣi gītā*	Paraśurāma	~ 17th Cen. C.E	Malayalam, Compendium
40.	*Vṛkṣāropaṇam*	--	~ 17th Cen. C.E	Agroforestry
41.	*Nuskha Dar Fanni-Falahat*	Dara Shikoh	~ 17th Cen. C.E	Persian translation of a *Vṛkṣāyurveda* text during the medieval period
42.	*Rista Dar Falaha*	Edited by M.		Persian translation of a

		Majumdar		*Vṛkṣāyurveda* text during the medieval period
43.	*Kūpaśāntividhi*	Baudhāyana	~ 18th Cen. C.E	Wells and Pond construction
44.	*Kṛṣikarma vidyā*	Rāmacandra sakhrama gupte	~ 18th Cen. C.E	In Marāṭhī – agriculture specific to Southern Maharashtra
45.	*Bhāratavarṣīya-vanauṣadhi-saṅgraha*	Paṇḍuranga gopala mantri	~ 18th Cen. C.E	Botanical lexicon of medicinal plants.
46.	*Kṛṣi śāsana*	Dasaratha śāstri	~ 19th Cen. C.E	Compendium of Agricultural practices. With Narayana Bhashya (Sanskrit)
47.	*Vanauṣadhi-darpaṇa*	Kavirāj Birācaraṇa gupta	~ 19th Cen. C.E	In Bengali – 2 volumes of Agriculture and Botany
48.	*Prācyabhāratīyam Ṛtu vijñānam*	Dhunīrāma tripāṭhī	~ 19th Cen. C.E	Agro-meteorology
49.	*Tāmbūlamañjari*		~ 19th Cen. C.E	Plant breeding – Areca nut, Beetle Creepers, etc. Agricultural techniques of

				Maharashtra region presented in 223 verses
50.	*Vanaspati*	G.P. Majumdar	1927	Review and compilation of various Ancient Agriculture and Botany.

Table No. 3.1 – Published texts of *Vṛkṣāyurveda*

In addition to these texts given in the table No. 3.1 , Purāṇa texts additionally have discussions on Agriculture in several chapters and passages, including various agricultural methods and agronomic practices. Some of these include the following Purāṇa text references:

- Agni-purāṇa – Chapters: 13, 70, 194, 246, 248, 281, 282.
- Padma- purāṇa – Chapter: 26
- Matsya- purāṇa – Chapters: 59, 154, 227, 255, 256, etc.

3.5.2 Unpublished *Vṛkṣāyurveda* manuscripts

The following Table No. 3.2 provides the list of *Vṛkṣāyurveda* manuscripts yet to be edited and published. These manuscripts are currently in the custody of various Oriental research institutes (ORI), Sanskrit heritage libraries, Manuscript libraries, and Private collections.

The details of these unpublished manuscript collections of *Vṛkṣāyurveda* are compiled from a number of sources including New Catalogus Catalagorum project, University of Madras, IGNCA (Indra Gandhi National Center for Arts); NaMaMi (National Manuscripts Mission) manuscript index,

Sanskrit medical manuscripts, National Institute of Indian Medical Heritage (NIIMH) and NDL of India (National Digital Library of India).

Sl. No.	Text name	Manuscript details	Institution /Location
1.	*Bījotpattiprakaraṇa*		Adyar library
2	*Kṛṣi śāstram* Arid /desert land agriculture using wild donkey and camel. Regional agricultural specific to South Rajasthan /Gujarat		GOML, Chennai
3.	*Vṛkṣopaniṣad*	D. I - 3030	ORI, Prayagraj
4.	*Vṛkṣāyurjñāna*	RORI. XII. 2984, p. 144 (No. 1490) of Ptd. Cat.	Udaipur
5.	*Vṛkṣārāma pratiṣṭhā*	Smṛti Pathabari. 1921. SB. New DC. II. I.8774	Dacca, Bangladesh
6.	*Vṛkṣārāmotsarga*	Grh. Bikaner 3857, NPS. V. p. 8 (inc.) TD. 14140 Tvm. Uni	Bikaner, Tiruvananthapuram
7.	*Vṛkṣādi vaikṛtaśānti*	GOML 88. MD. 3430. Mysore N.D.	Chennai

		IV. A 12433	
8.	*Vṛkṣodyāpana vidhi*	Kane, HDS, I.i.p.1108b	Nagpur University, Nagpur
9.	*Vṛkṣa dohatā prakāra*	Sl. No. 901, ABC 306, Shelf- 876	Tanjavur
10.	*Kūpa pratiṣṭhā vidhi* and *Jalotsargavidhi*	Sl. No. 3133, Cf. Auf. 1.114	A census of Indic manuscripts in the United States and Canada, H.I.Poleman – 1938. A reverse-index by David Pingree of the uncatalogued Sanskrit manuscripts listed by Poleman at Harvard University library
11.	*Jalāśayotsarga-prayoga*	Sl. No. 3135, UP. 128	-do-
12.	*Mayūracitraka* Agro-meteorology and Rain patterns		
13.	*Vṛkṣaropaṇa*		Darbhanga Raj library, Darbhanga, Bihar.
14.	*Kautuka-cintāmaṇi* - Gardening, manures, etc.	MSS No. 770, 10762A (B) /11041	Saraswati mahal library, Tanjavur,

		D	Tamil Nadu
15.	*Mānava-Vṛkṣāyurveda*' Large manuscript with 1600 shlokas spread in 22 Khāṇḍas.	MSS No. 195	Vallabha Vaishnava library, Nathwara, Rajasthan.
16.	'*Puṣpavāṭikā-vidhi*' - Flower gardening.	MSS No. 538	Ganganath Jha Research Institute, Prayagraj, UP.
17.	*Vṛkṣa dohada* - Fertilizers and gardening.	MSS No. 11305, II.3271	Saraswati Mahal Library, Tanjavur, Tamil Nadu
18.	*Vṛkṣa cikitsāropaṇādi vidhi*	Unpublished parts in Vishnu Dharmottara Purana	
19.	*Vṛkṣa pratiṣṭhā-vasudhārā-mantra*	SB. New DC II.i.8666	
20.	*Vṛkṣapratiṣṭhā-prayoga*	SB. New DC II.ii.11538	
21.	*Vṛkṣa bījalakṣaṇa*	L.889-A	Travancore University
22.	*Kṛṣi darśana - Mārkaṇḍeya-purāṇa*	177127, MDO00001615, NMM 138 A, 1-490	NMM, Delhi
23.	*Kṛṣi karma sāra-saṃgraha*	195545, ROI0000541942,	RORI, Jodhpur

		NMM 38588, 104	
24.	*Kṛṣipaddhati-jvarāvali*	14574, IGO001333697, AY/122, 282	OSM (Odisha State Museum)
25.	*Kṛṣikāṇḍam*	109469, RSO0000118328, 8279	ASS (Allahabad Sanskrit Sansthan)
26.	*Vṛkṣa Ayurveda'* (Devanagari script)	4653, DSO000013937, Accn. No. 531	ORL (Oriental Research Library), J&K
27.	*Vrikshadi Pratistha* (Sharada script)	1779-57 (Accn. No.), DSO0000110964	ORL (Oriental Research Library), J&K
28.	*Vṛkṣa pratiṣṭhā* (Sharada script)	1265-79 (Accn. No.), DSO000019023	ORL (Oriental Research Library), J&K
29.	*Vrksa pratiṣṭhā vidhi* (Sharada script)	725-120 (Accn. No.), DSO000015406	ORL (Oriental Research Library), J&K
30.	*Kṛṣi paṅcamī vratakathā'*	190668, ROI0000537218, 8525	RORI, Jaipur
31.	*Nāradakṛṣigāyatrīchanda*	190945, ROI0000537496, 8803	RORI, Jaipur

32.	*Kṛṣikarmasāra saṃgraha*	195545, ROI0000541942, 38588	RORI, Jodhpur
33.	*Dhannā-kṛṣi-nīsaṁjhāya*	209772, ROI0007460901, 11812-30	RORI, Bikaner in Prākrit
34.	*Krsi paddhati jvaravali*	14574, IGO-001333697, AY/122	Orissa State Museum, Bhubaneswar, Orissa

Table No. 3.2 – Unpublished texts of *Vṛkṣāyurveda*

It's to be understood that, many of the agricultural methods and techniques of Ancient India can be put to use for the development of agriculture and humanity at large through detailed study and experimentations based on many of these 100s of published as well as unpublished treatises and manuscripts of *Vṛkṣāyurveda*. These treatises provide time-tested and cost-effective solutions to many of the contemporary issues of agriculture.

3.6 *Vṛkṣāyurveda* in traditional agriculture

3.6.1 Historicity

Some agricultural scientists and Ayurveda scholars are of the opinion that the traditional agricultural practices of India are indeed based on *Vṛkṣāyurveda,* and are still in practice in many of the rural /tribal agricultural belts in India. With respect to India's Indigenous Technical Knowledge disciplines, it can be defined as *Vṛkṣāyurveda* is to India's ITK for agriculture just like what Ayurveda is to India's ITK for Health sciences.

The theoretical and scientific basis of India's traditional agricultural practices offered by *Vṛkṣāyurveda* was forgotten since the Mogul rule and British rule in India. This is due to the promotion of Persian and British practices and also the texts were created in Persian and English languages. This sudden shift in the traditional scientific knowledge management practices has resulted in the lack of deeper understanding of the integrated agro-ecological basis of *Vṛkṣāyurveda.*

Despite the lack of continuation of this traditional scientific discipline of Agricultural sciences during the past 500 years, some of the *Vṛkṣāyurveda* methods are still in practice without an understanding of the principles behind the practices.

In addition, the imposition of the Western methods of agriculture has resulted in the loss of this scientific discipline from both people's minds and widespread practices. The critical editing and publishing and translation of *Bṛhatsaṃhitā* in 1884 by Dr. Chidambaram Iyer and *Arthaśāstra* in 1907 by Dr. Shama Sastri has revived the interest in many of India's ancient sciences. Post publishing of *Arthaśāstra,* several ancient traditional scientific treatises were brought to limelight and published in book formats from Manuscripts.

Ancient Indian sciences were not given importance during the early days of colonial rule. During the late 19th century and early 20th century, several ancient scientific treatises of India were published with English translations. In particular, after the publication of encyclopedic texts such as, *Bṛhatsaṃhitā* and *Arthaśāstra Vṛkṣāyurveda* was getting popular to the scholar community in India.

Until the time the famous Indian Botanist Dr. G.P. Majumdar published the Botanical compendium called *Vanaspati* in 1927 and also critically edited and published the infamous *Upavana vinoda* - a popular *Vṛkṣāyurveda* text with English translation in 1934, there were no serious efforts to understand the ancient Indian agricultural sciences by the British rulers and also the British and European scientific community.

The famous agricultural treatise **'An Agricultural Testament' by Sir. Albert Howard**, by a renowned British Agricultural scientist, published in 1940, also highlighted **the superior methods of traditional Indian agricultural practices** which ensured better yields of crops such as rice, wheat and sugarcane. In addition, various biological and botanical characteristics of the produce were also found to be superior to that of those who are grown with other methods. Dr. Howard mentioned the traditional Indian agricultural practices as 'Indore Process' in his work.

3.6.2 ITK Implications

As per Food and Agricultural Organization (FAO) of United Nations, indigenous knowledge is closely associated with 'sustainable use and maintenance of a healthy and vibrant ecological system' – The International Assessment of Agricultural Knowledge, Science and Technology (AKST) report.

There are many examples of rejuvenating and regenerating the ecology and also supporting native, local livelihoods through indigenous knowledge systems in the world. These indigenous knowledge systems, if they are recorded, codified and in practice, then it becomes all the more important to preserve and follow those practices and methods as they are Indigenous,

sustainable and time tested solutions to the current ecological problems that the world is facing.

The International Assessment of Agricultural Knowledge, Science and Technology (AKST) commissioned by the World bank stresses the need for revival of the traditional and local knowledge systems, to promote Biodiversity, Water conservation, Soil fertility and also developing the capacity to withstand Climate change. The time tested Traditional wisdom which promotes Agriculture in harmony with nature is the need of the hour. It is therefore the need to go back to the traditional agricultural system which offers many traditional methods for the cultivation of traditional medicinal plants.

Post-independence, India was busy with managing multiple social problems including that of famine, poverty and also the pressing needs to improve food production to prevent infant mortality and malnutrition. This forced the administrators to tread the path of modern intensive agriculture. As part of the green revolution, intense agricultural practices with high water usage along with agro-chemicals were employed since 1970s. These methods and synthetic inputs for yield improvement and pest control were promoted aggressively across India.

However, many of these practices have resulted in nutritional challenges according to Indian Agriculture Research Institute (IARI), New Delhi during the President's address in 14th ASC 2019 conference.

Similarly, in many parts of the world agricultural expansion happened through agro-chemical based intensive agricultural practices. These practices

were focused only on yield, in other words 'output rather than outcome'. This has resulted in critical nutritional deficiencies in many countries and thus interest in Organic farming and traditional agricultural practices gained momentum throughout the world. In addition, several organic farming /traditional methods and inputs were brought to the limelight by many Agriculture focused NGOs all over the world.

During the 1990s famous Agricultural Scientist Dr. Yashvant Lakshman Nene, who served as the Dy. Director of ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) setup the Asian Agri-History Foundation (AAHF) post his retirement. Dr. Y. L. Nene along with few agricultural scientists and Sanskrit scholars did research into *Vṛkṣāyurveda.* Further, the researchers in AAHF critically edited and published over 10 *Vṛkṣāyurveda* treatises right from *Kṛṣi-Parāśara* to *kṛṣi-gīta* as part of a larger research for researching into the scientific and theoretical basis for India's time-tested ancient agricultural practices which are Organic and sustainable.

During early 2000s Government of India setup a high level ITK committee under the aegis of Indian Council for Agricultural Research (ICAR). This committee's responsibilities include the study various traditional agricultural practices and document the same. as part of India's Indigenous Technical Knowledge (ITK) in agricultural sciences. Subsequently, ICAR between the year 2002–2006 has formed a team of Agricultural scientists, and conducted Pan-India research and study on India's Indigenous Technical Knowledge (ITK) in agriculture.

These traditional agricultural practices have been well documented, field-experimented and validated during same period. ICAR has come out with a 7

volume database of Indigenous Technical Knowledge (ITK) in agriculture in the year 2005-06. Several practices that were codified by ICAR scientists in verbatim align with the ancient agriculture practices of *Vṛkṣāyurveda* texts. Therefore, these ITKs are not only widely practices but also have solid theoretical basis.

In conclusion, as a scientific discipline *Vṛkṣāyurveda* has been in practice since time immemorial in India. Many of the time-tested traditional agricultural practices in India are rooted in *Vṛkṣāyurveda*. Therefore, it is easy to adapt to these practices countrywide and can also be successfully merged with modern agricultural practices such as using agricultural machinery, poly-houses, micro irrigation methods, soil /water pH testing, remote sensing and precision farming methods.

From a farming standpoint, *Vṛkṣāyurveda* guides farmers, right from the selection of *deśa* / *bhūmi* (Agricultural land and soil), Field preparation – ploughing, Soil fertility management, Animal husbandry, Seed preparation, Planting, Botanical fertilizers, Pest and Insect control, Water management, Understanding of Seasons and Rain patterns, Water management, Plant growth, Harvest, Post-harvest management and Storage.

From a scientific standpoint, *Vṛkṣāyurveda* covers, ecology, Agroforestry, biology, plant morphology, histology and physiology, hydrology, water management, agro-meteorology, agronomy, seasons, rain patterns, soil management, seed management, seed treatment – for better germination, planting and sowing procedures, manuring and water regimen, plant nutrition deficiencies, harvests, storage methods, plant diseases, etc.

In reminder of the definitions and purpose of 'Vṛkṣāyurveda', which cover the entire gamut of agriculture, agroforestry and all allied activities - वृक्षायुर्वेदो नाम वृक्षादि-प्रसव-आरोप-पालनादि-कृति-विद्या - means 'the education of the science of Plants from germination, cultivation, maintenance, and to all allied activities' along with 'उपवन-दकार्गल-विज्ञान-तरु-रोपण-चिकित्सा-विधिः' and 'the rules of Agroforestry, Water management, Plant growth & treatment' as defined in Arthaśāstra and Kṛṣisāsana respectively.

Figure No.3.2, provides the ITK details of *Vṛkṣāyurveda* briefly. This figurative description covers only the major aspects to establish the facts and not specific methods or practices of *Vṛkṣāyurveda the* Indian agriculture ITK.

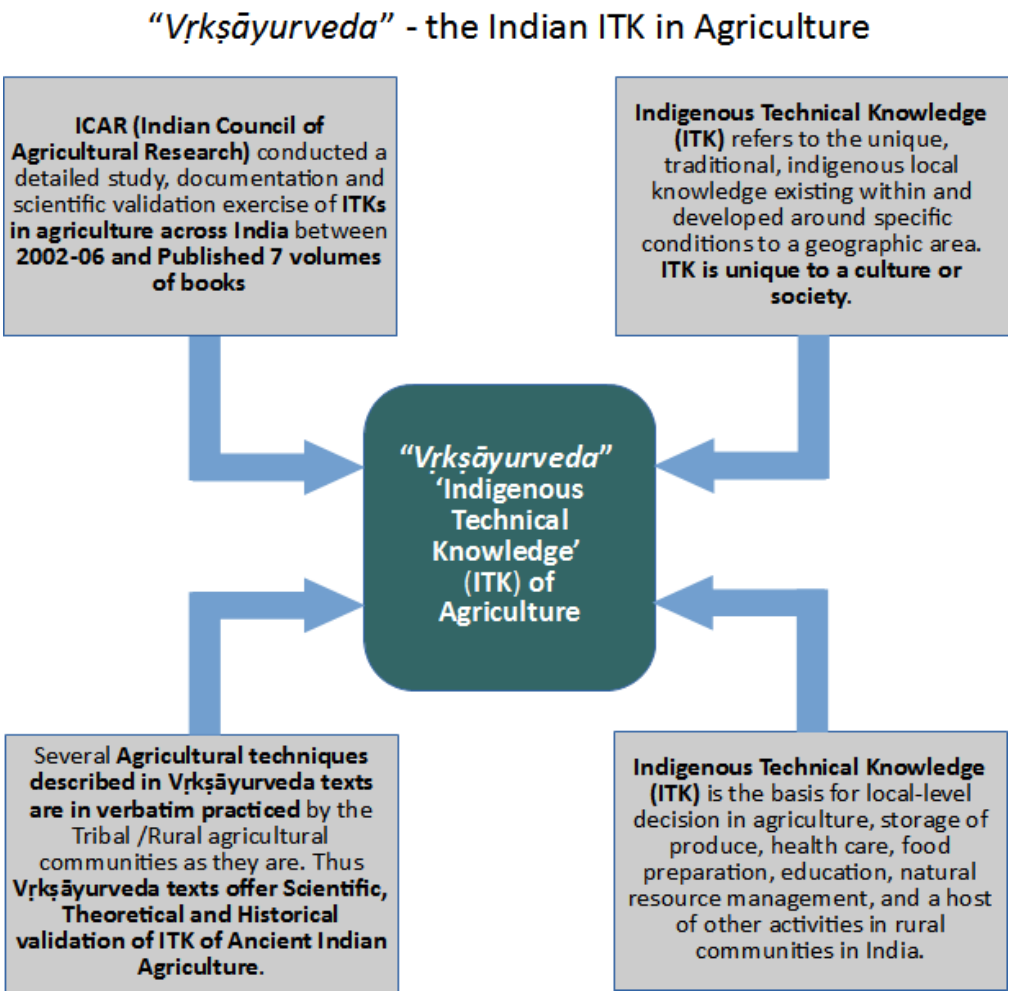

Figure No. 3.2 Vṛkṣāyurveda is the ITK in Indian Agriculture

Sir. Albert Howard (Agriculture scientist appointed by the British empire in the early 20th century confirmed the same while studying the traditional agricultural methods in 1924-1931 in Indore in central India. Albert Howard published all his findings in his monumental work 'An Agricultural Testament' (Oxford University Press, 1940)

3.6.3 Medicinal herbs and Tribal contributions

Though the vast amount of agricultural knowledge is codified in various Ayurveda *nighaṇṭu* (materia-medica) texts and *Vṛkṣāyurveda* texts, there are

still a considerable amount of plant knowledge remained with the farmers, cowherds and tribes.

This is clearly enumerated in *Caraka saṃhitā* and *Suśruta saṁhitā* the twin cannons of Ayurveda and also the Ayurvedic thesaurus in *Rājanighaṇṭu*' and in *Dhanvantarīya-nighaṇṭu*, in addition to the *Vṛkṣāyurveda'* texts – *Viśvavallabha*' and *Kāśyapīyakṛṣisūkti.*

Therefore, *Vṛkṣāyurveda* has always respected and codified the practical knowledge with respect to agriculture. Similar to various Sanskrit śāstras *Vṛkṣāyurveda* is also descriptive and not prescriptive in nature. The traditional knowledge in Agricultural practices were indeed codified as part of many *Vṛkṣāyurveda* texts. These facts are clearly indicated in the following statements, from various texts.

There are several plants which are suitable for cultivating in Agroforest and gardens. They can be learnt from the tribals by others[72]. Based on the advice of Gurus, and in accordance with the regional customs and order also based on own experience, logically and with full involvement one should be involved in agriculture[73].

Several medicinal plants' names and identification are known to shepherds, cowherds and tribals, a good (Ayurvedic) Doctor should learn

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72 रम्भादिकाः सन्ति च कन्दकाण्डजाताः तथा अन्येऽपि समूहनीयाः ।
आरामयोग्याः चतुरैः च पुम्भिः दृष्टाः च पृष्ट्वा वनवासिनो वै ॥ - *3.19, Viśvavallabha*

73 आर्याणामुपदेशात् च देशाचारक्रमादपि ।
तथा स्वानुभवाद् युक्त्या कृषिकर्मरता रताः ॥ - *1.409, Kāśyapīyakṛṣisūkti*

from them[74]. From cowherds, forest dwellers, hermits and others the knowledge about medicinal plants should be learnt[75].

One should learn about medicinal plants from cowherds, hermits, jungle dwellers and others. Subsequently, they should be thoroughly tested and then can be applied for medicinal purposes[76].

Probably the forest dwellers those who know medicinal plants which are very useful with their vernacular names. One should learn from them and use them accordingly[77].

3.7 Contemporary Agriculture and *Vṛkṣāyurveda*

Vṛkṣāyurveda promotes integrated poly-culture farming practices thus dependency on mono-culture and associated problems are prevented. *Vṛkṣāyurveda* methods offer **Organic and sustainable agricultural practices suitable for various crops and Indian agricultural zones** with different biological and ecological conditions.

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74 आर्याणामुपदेशात् च देशाचारक्रमादपि ।
तथा स्वानुभवाद् युक्त्या कृषिकर्मरता रताः ॥ - 1.409, Kāśyapīyakṛṣisūkti

75 गोपालास्तापसा व्याधा ये चान्ये वनचारिणः ।
मूलाहाराश्च ये तेभ्यो भेषजव्यक्तिरिष्यते ॥ - *37.11, Sūtrasthāna. Suśruta-saṃhita*

76 आभीरगोपालपुलिन्दतापसः पन्थास्तथा अन्येऽपि च वन्यापारगाः ।
परीक्ष्य तेभ्यो विविध-ओषध-अभिधारसादिलक्ष्माणि ततः प्रयोजयेत् ॥- *1.11, Rājanighanṭu*

77 प्रायो जनाः सन्ति वनेचराद्याः गोपादयः प्राकृतनामतज्ज्ञाः ।
प्रयोजनार्था वचनप्रवृत्तिर्यतस्ततः प्राकृतमित्यदोषः ॥ - *1.8, Dhanvantari-nighanṭu*

Vṛkṣāyurveda guarantees high agricultural yield coupled with low input costs, therefore is the most appropriate method to mitigate the current widespread problems of agriculture in India such as:

- Depletion of Soil fertility due to intense chemical farming methods
- Water scarcity and large scale depletion of ground water levels.
- Water toxicity due to improper usage of fertilizer and pesticides
- High input costs of – seeds, fertilizers and pesticides leading to high farmer indebtedness
- Lack of suitable QPM (Quality Propagation Material) – seeds and saplings plant choice and cultivation methods based on location, soil conditions and water availability
- Lack of appropriate low cost storage methods of harvested food products and herbal plants
- Toxins in food products and medicinal herbs due to the usage of chemical fertilizers and pesticides – WHO GACP standards

3.7.1 Water usage by sector and water stress in India

Due to intense agricultural practices using water intensive hybrid seeds which are dependent on Chemical fertilizers and pesticides since 1970s, India has almost lost the Eco-friendly, traditional *Vṛkṣāyurveda* methods and thus facing acute water crisis and soil degradation affecting agriculture and livelihood of the majority of the people. With the help of *Vṛkṣāyurveda,* water crisis issues and soil degradation issues can be rectified

Indiscriminate usage of Nitrogen fertilizers, over and above the recommended levels for the past 50 years have resulted in the increased

levels of soil acidity, alkalinity and salinity in major agricultural belts across India.

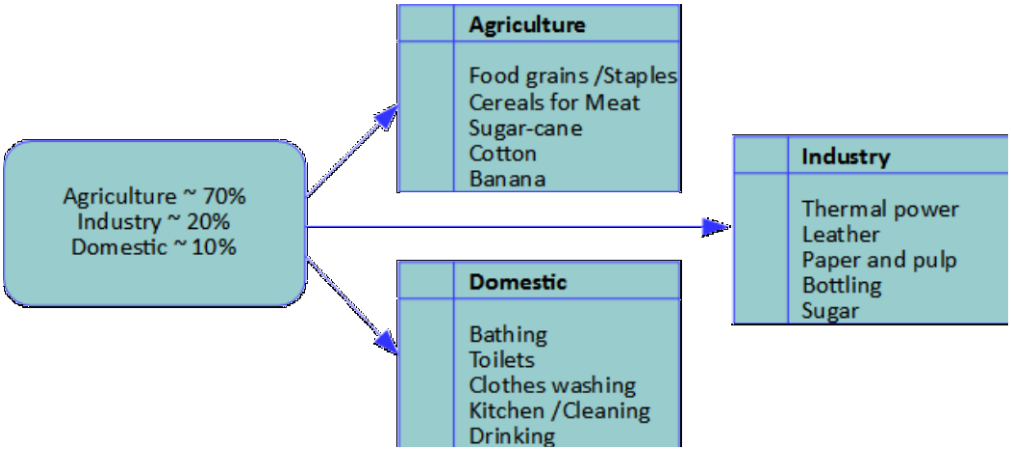

Figure No. 3.3 – Water usage in India by sector

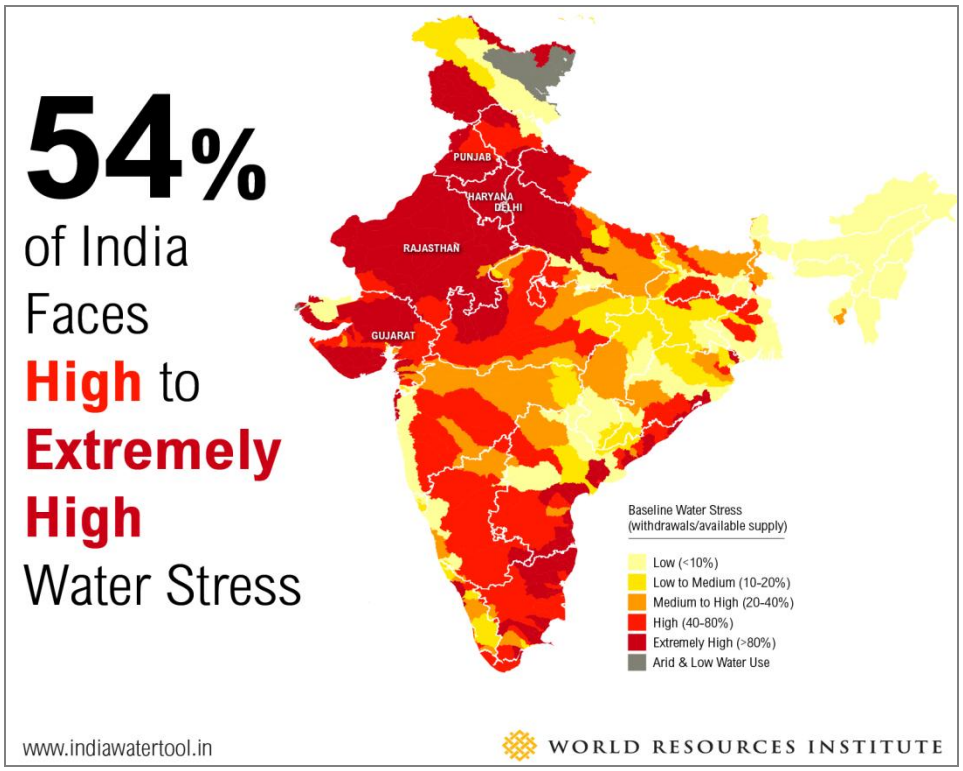

Figure No. 3.4 Water stress in India

3.8 *Vṛkṣāyurveda* and various Organic farming methods

Vṛkṣāyurveda has many unique natural methods which are quite distinctive compared to the conventional Organic farming. These methods are natural and integral with the natural cycles of crop and plant propagation, growth and sustenance. These are also highly suitable to the topographical and climatic condition for an integrated sustainable agriculture in the entire sub-continent region. Some of these are given below. A comparison of the *Vṛkṣāyurveda* method along with a similar independent conventional organic /sustainable farming method is given in Figure No.3.5.

Weather forecasting methods were based on sky watching as well as bird migratory patterns and insect migrations, in addition to the '*pancāṅga*' (weather almanac) based mathematical models of weather predictions.

Agroforestry methods to mimic the forest atmosphere, planting with low allelopathy and mutually supportive and compatible inter-crops which are suitable to the Indian peninsular region – this reduces the biotic stress faced by plants and can provide good yields without the need for additional inputs. In addition, Agroforestry model was in-vogue across India wherever the practice of' deva-*mātṛkā-kṛṣi'* (rain-fed agriculture) was done. This is due to the water saving needs and the agricultural field was being away from the water bodies such as rivers and lakes.

Several botanical addendums and inputs for Soil correction, Seed treatment, Germination and Fortification support, Plant growth and flowering support, etc. of *Vṛkṣāyurveda* were taken out of context and followed at random in many Organic farming methods of today and therefore they are lacking an integrated approach towards holistic farming.

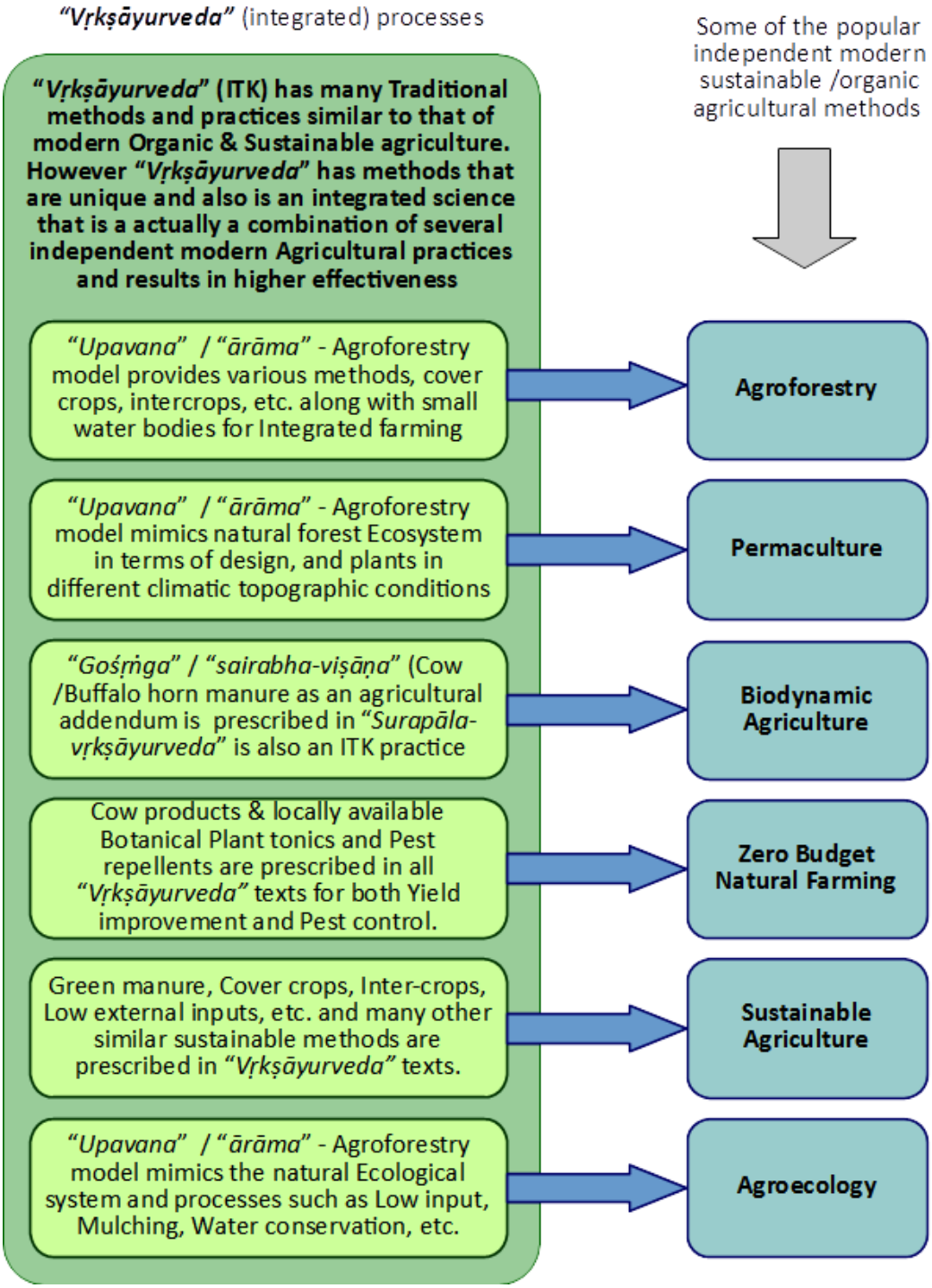

Figure No. 3.5 *Vṛkṣāyurveda* and various Organic farming methods

3.9 Botany in *Vṛkṣāyurveda*

Botanical aspects of plants have been studied and described since the Vedic times in Ancient India. Various plant parts have been described in *Vājasaneyī Saṃhitā* of *Śukla Yajurveda* and in *Taittirīya saṃhitā* of *Kṛṣṇa Yajurveda*[78].

Plant morphology as given in the Table No. 3.3 below were in vogue during Vedic times

मूलम् (Mūla)	Root
तूलम् (Tūla)	Panicle
काण्डम् (Kāṇḍa)	Stem
वल्शः (Valśa)	Twig
पुष्पम् (Puṣpa)	Flower
फलम् (Phala)	Fruit
स्कन्धः (Skandha)	Corona
शाखा (Śākhā)	Branch
पर्णम् (Parṇa)	Leaf

Table No. 3.3 Plant morphology

78 ओषधिभ्यः स्वाहा मूलेभ्यः स्वाहा तूलेभ्यः स्वाहा काण्डेभ्यः स्वाहा वल्शेभ्यः स्वाहा पुष्पेभ्यः स्वाहा फलेभ्यः स्वाहा । वनस्पतिभ्यः स्वाहा । - *Taittirīya Saṃhitā* – 7.3.19

The Figure No. 3.6, provides the details of high-level plant morphology according to the text *Vṛkṣāyurveda* of Parāśara. This text also contains details of further morphological details at leaf-level, flower level and fruit level.

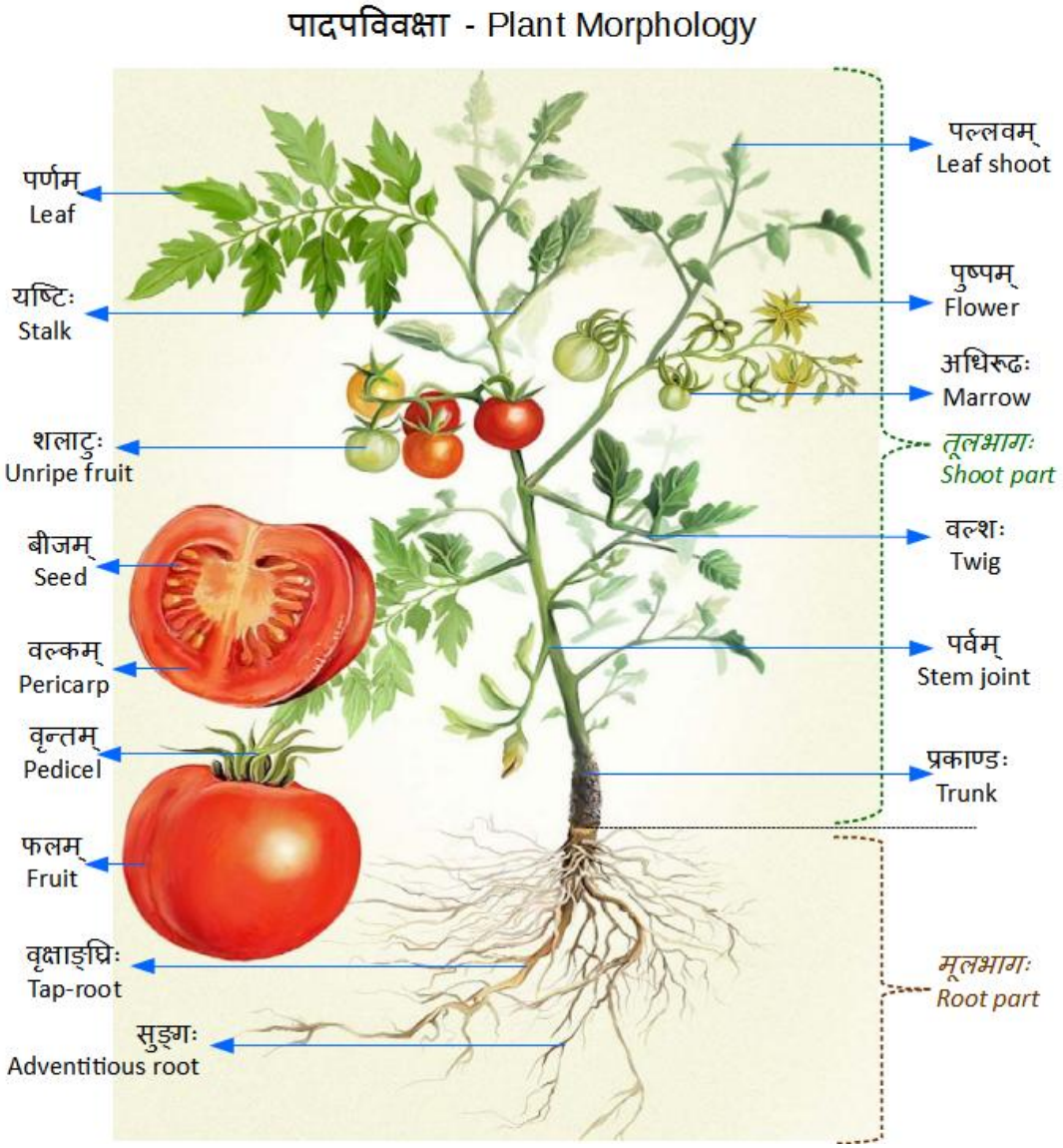

Figure No 3.6 Plant morphology in *Vṛkṣāyurveda*

Chapter 4: Agriculture and Agroforestry in *Vṛkṣāyurveda*

4.1 Kṛṣi - Agriculture

Over 20% of all Vedic literature deals with ऋतम् (*Ṛtam*) meaning the Universal cyclical order, the Harmony, the Natural equilibrium, the Sustaining power, the Recycling force, the birth-death cycles, etc. (the combination of all). All natural phenomenon such as Water cycles, Air cycles, Rains, Forests, Plants, etc. are all part this order. '*Dharma*' is the conscious alignment to that higher order.

The role of human being is defined to live in harmony with the nature and also harness the power of these natural cycles for spiritual emancipation according various *sāstra* texts including *Vṛkṣāyurveda*. The economic activities also play a crucial role with respect to sustainability of human life of Earth. *Kṛṣi* (agriculture) is the foremost among all pursuits of livelihood and economic activity during the Vedic times.

In support for agriculture, activities such as cattle management, irrigation system infrastructure, study of rain patterns are also covered in Vedas. However, Vedas instruct us to live and perform all economical activities in consonance with *dharma*.

Vṛkṣāyurveda, being a part of an *Upaveda,* covers the full spectrum of all activities of agriculture and Agroforestry (*upavanam*). *Vṛkṣāyurveda* distinctly differentiates all agricultural practices within the gamut of two major divisions of farming with respect to various processes right from Seed

preparation, soil management, irrigation, manuring, cultivation to harvest and storage. In these there are two main streams of agriculture.

The two major divisions are known as ***'kṛṣi-tantra'*** - which deals with the cultivation of ***'sasya'*** (crops and food grains) and ***'upavana-prakriyā'*** - which deals with the cultivation of rest of all ***'vṛkṣa'*** (all other plants such as vegetables, fruits, flowers, medicinal herbs and trees). Within many *Vṛkṣāyurveda* texts and also Agricultural ITK (Indigenous Technical Knowledge) practices, these two major classifications can be seen.

Atharvaveda gives more focus towards ***'kṛṣi-tantra'*** (cultivation of crops and food grains) in addition to animal husbandry. *Vṛkṣāyurveda* texts such as *Upavana Vinoda, Surapāla-Vṛkṣāyurveda, Abhilaṣitārtha Cintāmaṇi, Viśvavallabha*, etc. give more focus towards ***'upavana-prakriyā'*** or ***'upavana-pratiṣṭhā'*** - meaning setting-up of agroforests or vegetable gardens and cultivation of all kinds of plants including medicinal herbs. Texts such as Kāśyapīya kṛṣisūkti and Bṛhat-saṃhitā have separate chapters for both ***'kṛṣi-tantra'*** and ***'upavana-prakriyā'***. It's said that home, agricultural field, agroforestry, bridge, lake are the fundamental basis for *vāstu* [79] (human dwelling).

4.2 Kṛṣi-tantra - Cultivation of Food grains crops

kṛṣi-tantra model of agriculture focuses on the cultivation of food grains primarily on mono-crop model of agriculture where a single crop (food grain) is grown throughout the agricultural field with a common sowing and harvesting cycle.

[79] गृहं क्षेत्रम् आरामः सेतुबन्धः तटाकम् आधारः वा वास्तु । Arthaśāstra 3.8.1

4.2.1 State of agriculture in Ancient India.

Except the Ganga river plains and the rice belts (river basins) in Ancient India, most of the agriculture was centered in the model of Agroforestry. This was primarily based on the topographic nature of the fields. Therefore, poly-culture, different crops from herbs to mighty trees were cultivated.

Due to the famines in the early 20th century and post-independence, many of the farm lands have become food grain fields of mono-culture with yield being the only focal point. With the availability of free/subsidized electricity, farmers are pumping groundwater through deep-well pumps and using it for flood irrigation. Traditional practices such as, Water conservation, Soil health, Crop rotation, etc. were taken a back seat to intensive agricultural practices, high-yielding water intensive, fertilizer intensive hybrid seeds, high synthetic fertilizer usage and pesticides became the norm during the past 50 years in agriculture in India.

Historically, the ***kṛṣi-tantra*** model of agriculture, where the cultivation of 17 types of food grain/annuals (or) staples were followed in smaller area of agricultural lands in comparison to the ***Upavana-prakriyā*** (Agroforestry) model of agriculture. This was due to multiple reasons such as:

- Food grains are water intensive and also require high care, therefore farm-lands which were away from water-bodies, in particular away from the irrigation canals, followed the model of Agroforestry.
- Medicinal plants and spices were cultivated only in Agroforestry model and they had the highest economic potential for trade in historical India.

- Land topographic conditions and widespread forests across India influenced people to mimic the forest in the agricultural field where multiple crops are grown together – Agroforestry.

- Agroforestry model was the most suitable for small-farms (less than 2 hectare). Where most of the food product requirements including food grains, fodder, vegetables, fruits, medicinal plants and spices can be grown.

- Food grain cultivation was labour intensive coupled with low returns (in comparison with fruits/medicinal plants/spices). Therefore, historically majority of the Indian's agricultural lands followed the model of Agroforestry.

4.3 *'Upavana-prakriyā'* – Agroforestry establishment

Agriculture started as an activity where human beings have started doing by clearing forests which were offering food for all living beings. Therefore, in principle, agriculture should compensate for the loss of forests and therefore offer food not just for human beings but also for animals, birds and other life-forms – parts of the produce become food for human beings and rest (waste parts) can become food for other life-forms.

In addition, the agroforests (agricultural fields), which are maintained to mimic the forests with many multi-purpose plants used for food, medicinal and commercial purposes, are rightfully called as *Upavanam* (Agroforest) in ancient days as each one of them is an Agroforest and maintains a similar kind of Eco-system within itself.

In common usage of Sanskrit language, the words *'udyānam'* and *'upavanam'* are synonyms and denote gardens. However, these two are

different with respect to the *Vṛkṣāyurveda* texts (the agricultural science) where *'udyānam'* refers to garden and *'upavanam'* refers to 'Agroforest'.

The subtle differences are highlighted between garden and Agroforest clearly explained by describing the term *upavanam* in the following verse:

एते वृक्षाः शुभाः ज्ञेयाः प्रथमं तांश्च रोपयेत् ।
देवालये तथा उद्याने गृहेषु उपवनेषु च[80] ॥

*'These plants are sacred and are important; therefore, these need to be planted first in temples, **gardens**, homes and also in **Agroforest'**.*

The above verse from '*Bṛhat*-saṃhitā', an important ancient general scientific text, clearly explains that a simple garden and Agroforest are different from each other. In addition, the Upavana Vinoda (part of an Ayurveda text called śārṅgadhara-paddhati), itself was named based on the principle of *'upavanam'* (Agroforestry) due to the critical reason for the need to grow Medicinal Plants in *'upavanam'* model.

The term '*upavanam*' has got few other synonyms in various other *Vṛkṣāyurveda* texts, such as '*kṣetra vanam*' (क्षेत्रवनम्). This terminology literally means agricultural forest in the *Vṛkṣāyurveda* text 'upaskāra' and also as '*annapradhānam udyānam*' (अन्नप्रधानमुद्यानम्) in the text Parśara-*Vṛkṣāyurveda* and '*ārāma*' in many other works. All these signify that the agriculture model mainly for the cultivation of food grains and the multi-crop agroforestry model are different from each other.

[80] Kaśyapa, in Utpalavṛtti, Bṛhat-saṃhita 55.3

तिलानुप्त्वा तथा माषान् दृष्ट्वा पुष्पफलोर्जितान् ।
तस्मिन् उपवनं कुर्यात् क्रीडाशैले समन्ततः[81]

Sow '*tila*' (sesame) and '*maṣa*' (urad lentil) and in that land, ploughing them to the ground after flowering, establishes Agroforest completely.

The pictorial representation of Agroforestry models in *Vṛkṣāyurveda* is given in Figure 4.1 in the following page. This provides details such as the benefits of Agroforestry, modern and *Vṛkṣāyurveda* designs, Agroforestry designs in tropical and sub-tropical areas.

[81] Abhilaṣitārthacintāmaṇi Mānasollāsa 5.12

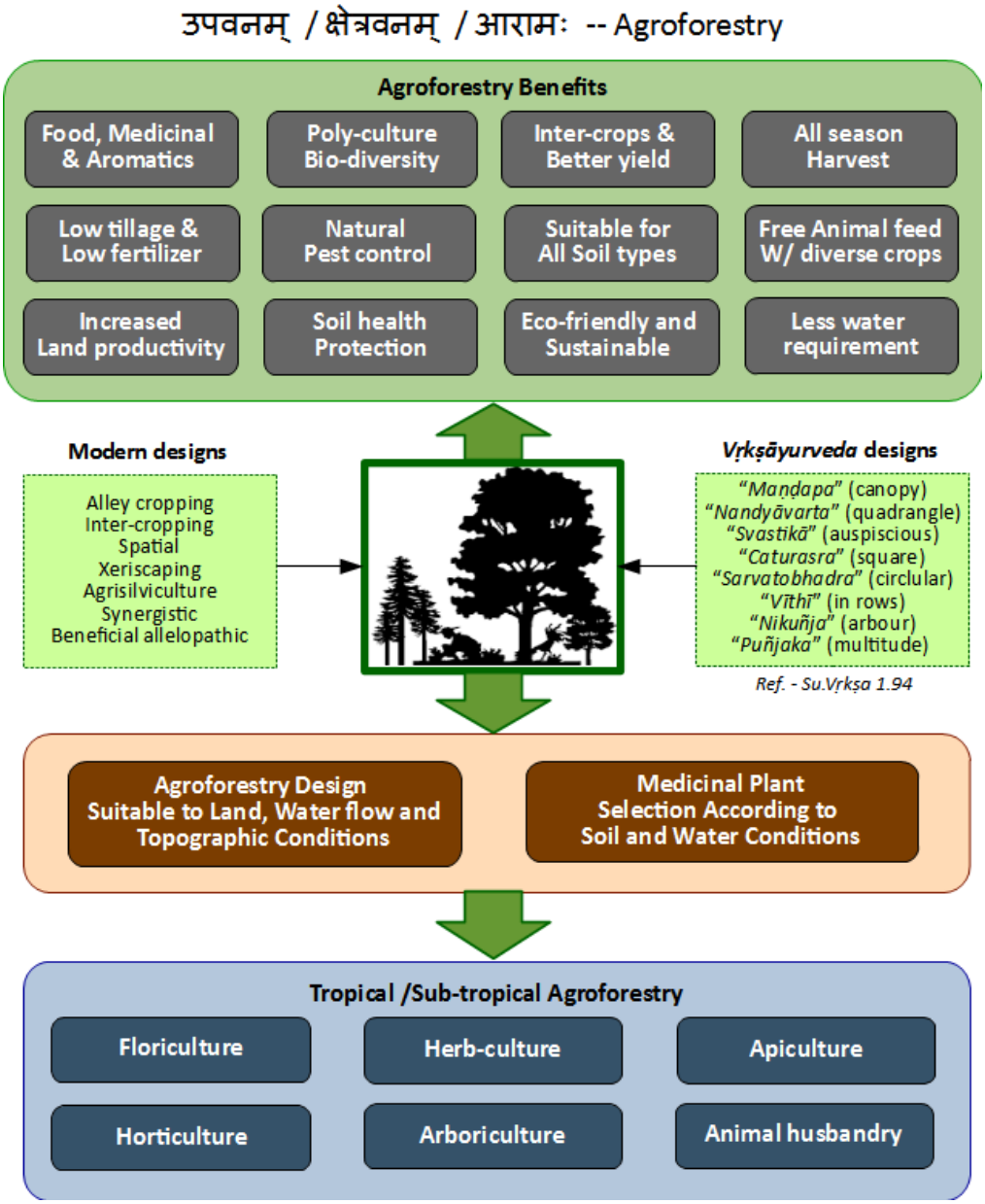

Figure No. 4.1 - Agroforestry models in *Vṛkṣāyurveda*

Sanskrit etymological cannon Nirukta of Yaskācārya gives the *'nirvacanam'* (description) of *'upavanam'* as *'upamitam vanena'* (उपमितं वनेन), meaning that which mimics the forest. Amarakosha, the lexicon defines it as *'kṛtrimam vanam'* (कृत्रिमं वनम्) meaning artificial forest and as *'ārāma'* (garden).

Therefore the text Upavana vinoda deals with agriculture/horticulture and not merely gardening. The concept of *'upavanam'* or Agroforestry was also common across India, Agroforest is known as *'vayalkāḍu'* in Tamil language. Which is a compound word formed by joining two words, *'vayal'* in Tamil meaning agricultural field and *'kāḍu'* meaning forest. Similarly, all ancient languages in India have distinct words for denoting Agroforest concept.

In addition to grains, cultivation of food trees, shrubs, creepers, and medicinal plants are also part of agriculture as mentioned in Arthasastra. *Vṛkṣāyurveda* texts such as Surapāla-*Vṛkṣāyurveda*, Upavana vinoda, Viśvavallabha, Mānasollāsa and few other texts are also dedicated for cultivation of various agricultural plants and trees in *'upavanam'* (Agroforestry) model.

'Upavanam' is the most appropriate model for the cultivation of medicinal plants as it mimics the forest environment. This coupled with the care and controlled cultivation as that of a vegetable garden makes it ideal. Thus the right amount of Abiotic and Biotic stress factors plays constructive role in increasing the efficacy in medicinal plants. Transplantation increases the life of the plant and is very similar to vaccination for a plant - it is most suitable for shrubs, small trees, food trees, and other plants suitable for *'upavanam'*.

Various types of plants that are grown in *'upavanam'* are classified in various ways. **According to Caraka-saṃhitā the most important Ayurvedic text, cultivated plants are classified as below**.

1. '*Udbhidyādi'* – Botanical – Flowers and Ornamental plants

2. '*Virecanādi'* – Medicinal – Herbal and Aromatic plants

3. '*Annapānādi'* – Food – Vegetable and Fruit plants

4.4 '*Upavanam*' (agroforestry) as the culture for conservation

4.4.1 Forests

In the ancient days the forests in India were classified into three types. They are –

(1) *mahāraṇya*/*mahāvana*/*rakṣa* (large animal-sanctuaries)

(2) *śrī vana* (large dense forests) and

(3) *khaṇḍavana* or *araṇya* (large area sacred forests).

The first type, *mahāraṇya*, is a sanctuary for wildlife where human beings are not allowed to enter, this includes tribal people. This kind of forests protect the wildlife and provide them a natural habitat for their cycle of life.

The second type, *śrīvana* is a dense forest. This type of forest was the property of the tribes and the people of a kingdom can't claim ownership in these protected lands. Responsibility for protecting this type of forest lies with the tribal/village communities and they protect the forests as their livelihoods depended on them.

The third type, *araṇya*, essentially covers a larger area, as big as a small state in today's India. This forest is the place for the protection and cultivation (by tribal) and preservation of medicinal plants, hermitages, various forest festivals, sacrificial rites etc. The practice of *vana mahotsava* (tree planting festival) is part of the ancient Indian tradition. Matsya purāṇa

describes this festival in detail. Additionally, Agni purāṇa says that the plantation of trees and creation of grooves and gardens lead to *svarga*.

The Arthaśāstra classifies land into 3 major types. 1) *Vana* which denotes the Forests and Hills and 2) *Kṣetra* denotes Agricultural Fields, Agroforests and Human settlements and 3) *Vraja* represents the Pasture and Grass lands.

In Arthaśāstra, protected *Vana* are further classified into '*mriga-vana'* (Deer forest), '*hasti-vana'* (Elephant sanctuary), '*Vyāla-vana'* (Wild animal sanctuary) '*pakṣi-vana'* (bird sanctuary), and *'dravya-vana* (forest produce/material sanctuary) or '*oṣadhi-vana'* (plant/medicine sanctuary). ***dravya-vana*** or ***oṣadhi-vana*** were the sources of forest produce including medicinal plants – this is the place where '**medicinal silviculture'** was widely practiced and medicinal plants were cultivated by the tribal people and this practice is still in vogue.

Arthaśāstra also mentions about the '*brahma araṇya'* - a forest where *vana-mahotsava* takes place and also other educational activities such as study of Vedas in hermitages which are located in the forest. Other types of forests in which religious activities used take place are *soma-araṇya* (forests for performing sacrificial rites) and ***tapo-vana*** (forests for ascetic hermitages/meditation). Many of these established forests, groves, agroforests, orchards and gardens are filled with medicinal plants providing leaves, flowers and fruits which have multiple healthcare benefits.

Deforestation, destruction and cutting trees were punished with fines and levies in ancient times. Forests being the anchors for maintaining the

ecological balance, they were protected by the Kings as a primary duty with equal importance as that of the protection of human settlements.

4.4.2 Constructed water bodies within 'Upavanam'

Lakes, tanks and ponds were constructed by the Kings of past in ancient India to support agriculture. Huge temple constructions with artificial water bodies were also part of construction activities in ancient India.

The tanks and ponds in temples were artificial reservoirs constructed to not just provide water to the priests, artisans and dwellers within the huge temple complex but also help in filling the underground aquifers. It is to be noted that the temples in dry areas were constructed with larger temple tanks. Depending on the size of the temple tank/pond, they were known as '*tīrtha*', '*sarovara*', '*puṣkariṇī*', '*kalyāṇī*', '*kuṇḍa*', '*vāva*' etc.

Water storage and management was an important part of a temple's structure in India. Many temple tanks, those in western and southern parts of India were large and elaborate with sculptures and artistic structures. Several beautifully constructed artistic temple tanks can be found in Hampi, Gujarat, Karnataka and Tamil Nadu. Many of them are geometrically designed step wells with aqueducts for water replenishment.

Step-wells are called '*Vāva* '(*Vāv*) in Gujarat region and some parts of Northern India. They were built by kings, dukes and village chiefs. Most of these *Vāva* were adorned with sculptures. Some of these *Vāva* also have dwelling places in two levels below ground for temporary stay during hot summer.

The famous Kāśyapīya-kṛṣi-sūkti has a dedicated chapter for the construction of water bodies and Irrigation canals with over 131 verses. When the land is examined whether it is suitable for water reservoir, shall be determined by the representatives of the King.

कृषियोग्या भूमिः इयम् उपवनाय इयम् आदृता ।
वनाय भूरियं प्रोक्ता जलाधारय निश्चिता[82] ॥

This land is fit for agriculture, this land is suitable for agroforestry/garden, this land is allotted for forests and this land is suitable for construction of reservoir (determined based on land type and geographical characteristics).

It also highlights that small water bodies shall be constructed by individual farmers and communities in their respective habitats.

4.4.3 Various medicinal groves (Sacred forests) - 'Auṣadhavana'

Important medicinal plants were cultivated and protected in the specially designated medicinal forests (*Vana*) and Agroforests (*Upavana*) and these groves were established specifically for various deeper purposes in addition to protection of medicinal plants and widespread availability of the same. These established Agroforests also had Religious and Spiritual significance based on:

- **Astrological significance of plants** – Plants for the 12 Zodiac signs, 27 Moon constellations and 9 Celestial bodies, which have subtle influence on human psychology
- **Worshiping substances** – leaves and flowers of Sacred plants which are used for performing pūjā (worshiping)

[82] Kāśyapīya-kṛṣi-sūkti 2.57

- **Meditative significance –** groves that are suitable for establishing hermitages for spiritual practice
- **Oblation and Salutations through plants** – obeisance to Gurus and Teachers which use to happen under specific plants and places

Rāśi-vana (Plants of 12 Zodiac signs)

The *Rāśi-vana* or zodiac grove consists of, trees and plants for all the 12 zodiac signs. These were designed for the purpose of good fortune by the people in various places. The medicinal plants in these groves were not only meant for their human medicinal in value but also for being food for various other life-forms. Therefore, these medicinal groves hold great anthropological, economic and ecological significance. Table No. 4.1 provides this information.

No.	*'Rāśi'* (Zodiac sign)	Plant /Botanical name	Medicinal usage
1	*Meṣa* (Aries)	*Raktacandana* (Pterocarpus santalinus)	Antioxidative, antidiabetic
2	*Vṛṣabha* (Taurus)	*Saptaparṇī* (Alstonia scholaris)	Hypertension, Malaria
3	*Midhuna* (Gemini)	*Panasa* (Artocarpus heterophyllus)	Rejuvanative, Anaemia
4	*Karkaṭa* (Cancer)	*Palāśa* (Butea monosperma)	Depurate, diuretic
5	*Simha* (Leo)	*Alivallabhā* (Stereospermum chelonoides)	Cardio protective
6	*Kanyā* (Virgo)	*Āmra* (Mangifera indica)	Antiseptic, Asthma, etc.
7	*Tulā* (Libra)	*Bakula* (Mimusops elengi)	Astringent, Anthelmintic
8	*Vṛścika* (Scorpio)	*Khadira* (Acacia catechu)	Colitis, osteoarthritis
9	*Dhanuṣ* (Sagittarious)	*Aśvattha* (Ficus religiosa)	Reproductive health, etc.
10	*Makara* (Capricon)	Ṣiṃśapa (Dalbergia sissoo)	Syphilis, Asthma

11	*Kumbha* (Aquarius)	*Śamī* (Prosopis cineraria)	Leprosy, leucoderma
12	*Mīna* (Pisces)	*Nyagrodha* (Ficus bengalensis)	Fever, Anti-infammatory

Table No. 4.1 - Medicinal plants of 12 Zodiac signs

Nakṣatra-vana (Plants of 27 Lunar constellations)

The Nakṣatra-vana consists of the corresponding medicinal plants for the 27 constellations on the path of the Moon in the lunar cycle. It is to be noted that these plants also follow the lunar cycles with respect to biological functions such as flowering, pollination, germination, etc. The following table 4.2 provides corresponding information.

No.	Constellation	Plant /Botanical name	Medicinal usage
1	Aśvinī	*Kāraskara* (Strychnos nux-vomica)	Reproductive healthcare
2	Bharaṇī	*Dhātrī* (Embilica officionalis)	Immunity, Rasayana, etc.
3	Kṛitikā	*Udumbara* (Ficus glomerata)	Chemopreventive
4	Rohiṇī	*Jambū* (Syzygium jambolanum)	Coolant, Diabetes, etc.
5	Mṛgaśira	*Khadira* (Acacia catechu)	Colitis, osteoarthritis
6	Ārdrā	*Śiṃśapā* (Dalbergia sissoo)	Eyecare
7	Punarvasu	*Vamśa* (Bambusa bambos)	Diabetes, Carminative
8	Puśyāmī	*Aśvattha* (Ficus religiosa)	Reproductive health, etc.
9	Āśleṣā	*Nagakesara* (Mesua ferrea)	Menustral healthcare
10	Maghā	*Nyagrodha* (Ficus bengalensis)	Fever, Anti-infammatory
11	Pūrvāphalgunī	*Palāśa* (Butea monosperma)	Depurate, diuretic
12	Uttarāphalgunī	*Plakṣa* (Ficus virensait)	Diabetes, liver tonic
13	Hastā	*Ariṣṭa* (Sapindus mukorossi)	Hepato-protective
14	Citrā	*Bilva* (Aegle marmelos)	Digestive healthcare
15	Svātī	*Arjuna* (Terminalia arjuna)	Cardio protective
16	Visakhā	*Vikankata* (Flacourtia indica)	Arthritis, immunity
17	Anurādhā	*Bakula* (Mimusops elengi)	Astringent, Anthelmintic
18	Jyeṣṭhā	*Sarala* (Pinus roxburghi)	Infection, wound healing

19	Mūlā	*Sarja* (Shorea robusta)	Wound and Pain care
20	Pūrvāṣāḍhā	*Vetasa* (Calamus rotang)	Diabetes, diarrhea, etc.
21	Uttarāṣāḍhā	*Panasa* (Artocarpus heterophyllus)	Rejuvanative, Anaemia
22	Śravaṇam	*Arka* (Calotropis gigantia)	Leprosy, Cardioprotective
23	Dhaniṣṭhā	*Śamī* (Prosopis spicigere)	Diarrhoea
24	Śatabhiṣak	*Kadamba* (Anthocephalus cadumba)	Rhematism, cough, etc.
25	Pūrvābhādrapadā	*Āmra* (Mangifera indica)	Antiseptic, Asthma, etc.
26	Uttarābhādrapada	*Nimba* (Azardirachta indica)	Antimicrobial, Leprosy
27	Revatī	*Madhuka* (Madhuca indica)	Anti-infammatory, etc.

Table No. 4.2 - Medicinal plants of 27 Constellations

Navagraha-vana (Plants of Nine Celestial bodies)

Nāgara-khāṇḍa[83] of Skānda-purāṇa, describes the importance of Navagraha-*vana.* Post medieval times *Navagraha* (the nine celestial bodies which subtly influence life-forms on Earth particularly their psyche) were started getting installed as deities, in a separate sanctum in many temples. However, during historical times the nine celestial bodies were worshiped in the form of tress and people used to erect the *Upavanam* (Agroforest) specifically to worship them. This had the purpose of astrological significance as well as medicinal and ecological significance. Table 4.3 demonstrates the celestial bodies and corresponding plants –

No.	'*Navagraha*' (Celestial body) Circular direction	Plant /Botanical name	Medicinal usage in Traditional Healthcare
1	*Sūrya* (Sun) - Center	*Arka* (Calotropis procera)	Leprosy, Cardio-protective
2	*Candra* (Moon) - South East	*Palāśa* (Butea monosperma)	Depurate, diuretic
3	*Mangala* (Mars) - South	*Khadira* (Acacia catechu)	Colitis, osteoarthritis
4	*Budha* (Mercury) - North East	*Apāmārga* (Achyranthes aspera)	Hemorrhoids, indigestion

[83] Skānda-purāṇa 6.252.35-40

5	*Guru* (Jupiter) - North	*Aśvattha* (Ficus religiosa)	Reproductive care...
6	*Śukra* (Venus) - East	*Udumbara* (Ficus glomerata)	Chemo-preventive, Diabetes
7	*Śani* (Saturn) - West	*Śamī* (Prosopis cenneraria)	Diarrhoea
8	*Rāhu* (North lunar node) South-West	*Dūrvā* (Cynodon dactylon)	Diabetes, Blood purification
9	*Ketu* (South lunar node) - North-West	*Kuśa* (Desmostachya bipinnata)	Radiation protection, Menstrual health.

Table No. 4.3 - Medicinal plants of Navagraha (Navagraha Vana)

Daśapuṣpa-vana (Plants of 10 sacred flowers)

The following table No. 4.4 describes the 10 sacred flower plants that are prescribed to be grown in human settlements for regular daily worship purposes. Their medicinal properties are also given.

No.	*'Puṣpa'* (Flower)	Botanical name	Medicinal usage in Traditional Healthcare
1	*Lajjālu*	Biophytum sensitivum	Cardio-tonic, inflammation
2	*Bhadrā*	Aerva lanata	Cholera, diuretic
3	*Sakralatā*	Cardiospermum halicacabum	Nervous disorders
4	*Lakṣmaṇā*	Ipomoea *sepiaria*	Anti-ulcer, Rejuvenative
5	*Sahadevī*	Vernonia cineria	Chemo-preventive
6	*Dūrvā*	Cynodon dactylon	Cardio-tonic, carminative
7	*Muśalī*	Curculigo orchioides	Blood purification, Piles
8	*Vishṇukrānti*	Evolvulus alsinoides	Febrifuge, Cough
9	*Bhṛṅgarāja*	Eclipta alba	Asthma, Fever, Gastro
10	*Śaśaśruti*	Emilia sonchifolia	Expectorant, febrifuge

Table No. 4.4 - Ten medicinal flower plants - Daśapuṣpa-vana

Saptamātṛkā-vana (Plants of 7 aspects of celestial motherhood)

No.	*'Mātṛkā'* (mothers)	Plant/botanical name	Medicinal usage in Traditional Healthcare
1	Brāhmaṇī	*Palāśa* (Butea monosperma)	Depurate, diuretic
2	Vaiṣṇavī	*Rāja-vṛkṣa* (Cassia fistula)	Anti-inflammatory
3	Māheśvarī	*Puṇḍarika* (Nelumbo nucifera)	Cardio-protective
4	Cāmuṇḍā	*Ajāji* (Ficus lacor)	Chemo-preventive, Diabetes
5	Indrāṇī	*Kalpakā* (Cocos nucifera)	Coolant, Rejuvanation
6	Vārāhī	*Nyagrodha* (Ficus bengalensis)	Dental health, Diabetes
7	Kaumārī	*Plakṣā* (Ficus glomerata)	Chemo-preventive, Diabetes

Table No. 4.5 Medicinal plants of Seven mothers - Saptamātṛkā-vana

Hence it is very appropriate to say –

यावत् भूमण्डलं धत्ते सशैलवनकाननम् ।
तावद् तिष्ठति मेदिन्यां सन्ततिः पुत्रपौत्रिकी[84] ॥

Human generations exist in this world, so long as the plants, hills and forests exist' proclaims this sacred hymn.

Arunācala-vana (Plants of 12 Flowers and leaves)

The Skānda-purāṇa[85] describes the importance of cultivation of Arunācala-vana, which consists of the flowers and fruits that are offered during the 12 months of Hindu calendar. Post worship the flowers are to be worn in the ear or head and the fruits to be eaten to absorb their prophylactic qualities. The following table No. 4.6

[84] Durgāśaptasatī, Kavacam 1.4.8

[85] Skānda-purāṇa, Māheśvarakhāṇḍa, Aruṇāchalamāhātmya 1.2.44

No.	Month	Flower/Botanical name & Medicinal qualities	Fruit/Botanical name & Medicinal qualities
1	*Caitra* (Apr-May)	अशोकम् (Saraca indica) Reproductive healthcare	दाडिमम् (pomegranate) Renal protection
2	*Vaiśāka* (May-Jun)	मल्लिका (Jasminum indicum) Sleep inducive, Calming	नालिकेरम् (Cocus nucifera) Digestive health, Coolant, Skin
3	*Jyeṣṭha* (Jun-Jul)	पाटलम् (*Bignonia chelonoides*) Cardio-tonic, Calming	आम्रम् (Mangifera indica) Antiseptic, Asthma, etc.
4	*Āṣāḍha* (Jul-Aug)	कदम्बकम् (Haldina cordifolia) Anti-biliousness, digestive	पनसम् (Artocarpus heterophyllus) - Rejuvanative
5	*Śrāvaṇa* (Aug-Sep)	करवीरम् (Nerium indicum) Syphilis, Skincare, etc.	कर्जुरम् (dates) Blood purification
6	*Bhādrapada* (Sep-Oct)	जातिः (Jasminum grandiflora) Headache, Skincare, etc.	तालः (palmyra-fruit) Digestive healthcare, coolant
7	*Aśvina* (Oct-Nov)	मालती (Aganosma heynei) Rheumatism, etc.	आमलकम् (Embilica officinalis) Immunomodulation
8	*Kārtika* (Nov-Dec)	शतपत्रः (Nelambu nucifera) Cardio-tonic, Immuneo-boost	बिल्वम् (Aegle marmelos) Digestive healthcare
9	*Mārgaśīrṣa* (Dec-Jan)	उत्पलम् (*Nymphaea alba)* *Cardio-tonic, sleep disorders*	कमला (Citrus aurantium) Respiratory health, Immunity
10	*Pauṣa* (Jan-Feb)	वसन्ती (*Hiptage benghalensis)* *Anti-infammatory, Wounds*	पूकम् (*Areca* catechu) Bioavailability
11	*Māgha* (Feb-Mar)	कुन्दः (Jasminum multiflorum) jaundice, veneral diseases	कर्मरङ्गः (Averrhoa carambola) Anti-ulcerogenic
12	*Phālguna* (Mar-Apr)	पुन्नागः (Calophyllum inophyllum) - Tuberculosis	जातीफलम् (jatīphalam Asthma, respiratory health

Table No. 4.6 Medicinal plants & flowers for the worship of the sacred hill Arunachala - Arunācala-vana

Ganeśa-ekavimśati-vana (21 plants in Ganeśa worship)

Leaves of the following 21 medicinal plants are used in *Sri. Ganeśa* worship. At the end of the worship, these leaves are put in the incense and the smoke from the incense purifies the air and also is causes to happen an aromatherapy. Table No. 4.7 below gives the details of these sacred medicinal plants.

No	Plant	Botanical name	Medicinal usage
1	माची	*Mācī* (Artemisia vulgaris)	Pain relief
2	बृहती	*Bṛhatī* (Solanum indicum)	Asthma, cough
3	बिल्वम्	*Bilva* (Aegle marmelos)	Digestive healthcare
4	दूर्वा	*Dūrvā* (Cynodon dactylon)	Cardio-tonic, carminative
5	धत्तूरः	*Dhattūra* (Datura metel /stramonium)	Anti-asthmatic, Antispasmodic
6	बदरी	*Badarī* (Ziyphus mauritiana)	Digestive, Hepato-protective
7	अपामार्गः	*Apāmārga* (Achyranthes aspera)	Hemorrhoids, indigestion
8	तुलसी	*Tulasī* (Ocimum sanctum)	Antimicrobial, Respiratory
9	चूतम्	*Cūta* (Mangifera indica)	Antiseptic, Asthma, etc.
10	करवीरः	*Karavīra* (Nerium indicum)	Syphilis, Skincare, etc.
11	विष्णुक्रान्ता	*Viṣṇukrāntā* (Jasminum angustifolium)	Nerve tonic
12	दाडिमम्	*Dāḍima* (Punica granatum)	Reproductive, Renal, etc.
13	देवदारुः	*Devadaru* (Cedrus deodara)	Neurology, Respiratory, etc.
14	मरुवः	*Maruva* (Ocimum basilicum)	Respiratory, digestive
15	सिन्धुवारः	*Sindhuvāra* (Vitex trifolia)	Anti-inflammatory, antimicrobial

16	जाती	*Jātī* (Jasminum grandiflorum)	Calming
17	अगस्ती	*Agastī* (Agati grandiflora)	Immuneo-boost
18	शमी	*Śamī* (Prosopis spicigera)	Rheumatism, Cough
19	अश्वत्थम्	*Aśvattha* (Ficus religiosa)	Reproductive healthcare
20	अर्जुनः	*Arjuna* (Terminalia arjuna)	Cardio-protective
21	अर्कः	*Arka* (*Calotropis gigantea*)	Leprosy, Cardio-protective

Table No. 4.7 – Medicinal plants for Ganesha worship - *Ganeśa ekavimśati-vana*

Jaina tīrthaṅkara-vana (Plants of 24 Jain Gurus)

The Jaina religious people were worshiping their 24 Tīrtaṅkaras (Enlightened beings) by growing the associated plant in a medicinal forest. This kind of medicinal silviculture helped the Jain renunciate to take refuge there to perform meditation and attain *Nirvāṇa* (liberation), table 4.8 below provides the details of these plants.

No	'Tīrtaṅkara' (Guru)	Plant /botanical name	Medicinal usage
1	*Ādinātha*	*Nyagrodha* (Ficus bengalensis)	Fever, Anti-inflammatory
2	*Ajitanātha*	*Śāla* (Vatica robusta)	Diabetes, Wound healing
3	*Sambhavanātha*	*Śāla* (Vatica robusta)	Diabetes, Wound healing
4	*Abhinandanātha*	*Veśali* (Callicarpa arborea)	Diarrhea, Ulcerative colitus
5	*Sumatinātha*	*Priyaṅgu* (Aglaia elaeagnoidea)	Anti-inflammatory, coolant
6	*Padmaprabha*	*Nyagrodha* (Ficus bengalensis)	Fever, Anti-infammatory
7	*Suparśvanātha*	*Śirīṣa* (Albizia lebbeck)	Anti-poison, Anti-bacterial
8	*Candraprabha*	*Nāgadruma* (Mesua ferrea)	Rheumatism, scabies
9	*Suvidhinātha*	*Mallikā* (Jasminum indicum)	Aromatherapy, Nerve tonic

10	*Śaitalanātha*	*Bilva* (Aegle marmelos)	Digestive, carminative
11	*Śreyasanātha*	*Tiṇḍuka* (Diospyros malabarica)	Urinary tract infections
12	*Vasupūjya*	*Kadamba* (Neolamarckia cadamba)	IBS, ulcers, diarrhea,
13	*Vimalanātha*	*Jambu* (Syzigiyam jambolanum)	Diabetes, Carminative
14	*Anantanātha*	*Aśvattha* (Ficus religiosa)	Reproductive health, etc.
15	*Dharmanātha*	*Saptaparṇa* (Alstonia scholaris)	Malaria, Ulcers, etc.
16	*Śāntinātha*	*Nandi-vṛkṣa* (Ficus arnottiana)	Skin care
17	*Kunthunātha*	*Tilaka* (symplocos racemosa)	Diarrhea and eyecare
18	*Aranātha*	*Āmra* (Mangifera indica)	Antiseptic, Asthma, etc.
19	*Māllīnātha*	*Aśoka* (Saraca indica)	Reproductive healthcare
20	*Munisuvrata*	*Campakā* (Magnolia champaca)	Cardiac disorders, gout
21	*Nāminātha*	*Bakula* (Mimusops elengi)	Astringent, Anthelmintic
22	*Neminātha*	*Vetasa* (Salix tetrasperma)	Diabetes, Piles, Epilepsy
23	*Parśvanātha*	*Dhātakī* (Woodfordia fruticosa)	Diarrhea, Piles, etc.
24	*Mahāvīra*	*Śāla* (Vatica robusta)	Diabetes, Wound healing

Table No. 4.8 Medicinal plants of Jaina Gurus - Tīrthaṅkara-vana

Mānuṣī Buddha-vana (Plants of 7 human Buddhas)

In Buddhism, sacred (medicinal) plants are associated with each Buddha before Siddhārtha Gautama. It was considered among Buddhists that growing these trees and meditating among them help in attaining *Nirvāṇa*. The following table No. 4.9 details these plants

No.	***'Mānuṣī Buddha'*** **(Liberated one)**	**Plant /botanical name**	**Medicinal usage in Traditional Healthcare**
1	*Vipaśvī*	*Aśoka* (Saraca indica)	Reproductive healthcare
2	*Sikhī*	*Puṇḍarīka* (Nelumbo nucifera)	Heart tonic, General health
3	*Vessabhū*	*Śāla* (Vatica robusta)	Diabetes, Wound healing
4	*Kakut sandha*	*Śirīṣa* (Albizia lebbeck)	Anti-poisoning, Anti-bacterial

5	*Koṇāgamana*	*Udumbara* (Ficus glomerata)	Chemopreventive, Diabetes
6	*Kāśyapa*	*Nyagrodha* (Ficus bengalensis)	Fever, Anti-infammatory
7	*Gautama*	*Aśvattha* (Ficus religiosa)	Reproductive health, Asthma

Table No. 4.9 Medicinal plants of Liberated ones - Mānuṣī Buddha-vana

Pañcabhūta-vana (Plants of 5 Primordial Elements)

The Pañcabhūtas – Pṛthvī (Earth), Āpaḥ (Water), Tejas (Fire), Vāyu (Air) and Ākāśa (Space) are the primordial elements described in the Veda and all śāstra texts including Ayurveda and *Vṛkṣāyurveda* texts. The following table 4.10 lists the famous Pañcabhūta plants.

No.	'Bhūta' (Primordial Element)	Plant/Botanical name	Medicinal usage in Traditional Healthcare
1	*Pṛthvī* (Earth)	*Āmra* (Mangifera indica)	Antiseptic, Asthma
2	*Āpa* (Water)	*Jambu* (Syzigiyam Jambolanum)	Diabetes, Carminative
3	*Tejas* (Fire)	*Bakula* (Mimusops elengi)	Astringent, Anthelmintic
4	*Vāyu* (Air)	*Bilva* (Aegle marmelos)	Digestive healthcare
5	*Ākāśa* (Space)	*Ugaru* (Excoecaria agallocha)	Ulcers, Purgative

Table No. 4.10 Medicinal plants of Primordial elements - Pañcabhūta-vana

Pañcavaṭī-vana

Pañcavaṭī means 'place of five Vaṭa (big) trees.' This has historical significance as these denote the place where Sri Rama and Sita had their hermitage for a long period during their exile in forest described in Rāmayaṇa. This Upavanam primarily has five big trees in it. Each one of these trees has multiple medicinal properties as shown in table 4.11.

No.	Plant	Botanical name	Medicinal usage in Traditional Healthcare

1	अशोकम् (*aśoka*)	Saraca indica	Reproductive healthcare
2	अश्वत्थः (*aśvattha)*	Ficus religiosa	Reproductive health, Asthma
3	बिल्वम् (*bilva*)	Aegle marmelos	Digestive health, carminative
4	न्यग्रोधः (*nyagrodha*)	Ficus bengalensis	Fever, Anti-infammatory
5	आमलकी (*āmalakī*)	Phylanthus emblica	Rasāyana, Immuno-modulation

Table No. 4.11 - The five sacred medicinal trees - Pañcavaṭī-vana

Tapo-vana (Meditation grove)

The sacred trees with multiple ecological and medicinal benefits are primarily members of the Tapo-vana groves. These trees also keep the environment clean in addition to their scents from pollen offers natural aromatic and therapeutic atmosphere. The following description shows some of the famous Tapo-vana trees.

1). ***Aśvattha*** (Ficus religiosa), 2). ***Udumbara*** (Ficus glomerata) 3). ***Nyagrodha*** (Ficus bengalensis), 4). ***Śālmalī*** (Bombax ceiba), 5). ***Aśoka*** (Saraca indica), 6). ***Āmalakī*** (Embilica officinalis), 7). ***Bibhitakī*** (Terminalia chebula), 8). ***Haritakī*** (Terminalia bellerica), 9). ***Nimba*** (Azadirachta indica), 10). ***Varuṇa*** (Crataeva religiosa), 11). ***Khadira*** (Acacia catechu), 12). ***Kimśuka /Palāśa*** (Butea monosperma), 13). ***Śāla*** (Vatica robusta), 14). ***Śamī*** (Prosopis cineraria), 15). ***Āmra*** (Mangifera indica), 16). ***Badari*** (Ziziphus jujuba), 17). ***Jambū*** (Syzigiyam Jambolanum), 18). ***Bilva*** (Aegle marmelos), 19). ***Arjuna*** (Terminalia arjuna), 20). ***Aragavadha*** (Cassia fistula), 21). ***Kapittha*** (*Feronia elephantum), 22).* **Kārpāsa** *(Gossypium arboreum), 23).* ***Bakula*** *(Mimusops elengi), 24).* ***Khadira*** *(Acacia catechu)*

Medicinal usage for these plants in the traditional healthcare system is covered in other listings of groves as many of these plants are overlapping with other Sacred list of plants of various groves.

Ṛṣi-vana (Sages grove)

The *Ṛṣi vana* (including *Sapta-Ṛṣi-vana*) historically was considered as the homage and gratitude for the Sages. Planting of these medicinal plants take place during the *Guru pūrṇimā* festival (Summer solstice and also the rainy season). Planting these plants were considered as the *Guru-dakṣiṇā* for studying the Vedas, *śāstra, itihāsa* and *purāṇa* – which were considered to be the core parts of education along with Agriculture and Economics. The following table offers the list of *Ṛṣi* and the associated medicinal plants.

No.	Ṛṣi (Sage)	Plant /Botanical name	Medicinal usage in Traditional Healthcare
1	*Atri*	*Kumudam* - Nymphaea alba	Heart tonic, Anti-anxiety
2	*Agastya*	*Agastya* (Sesbania grandiflora)	Digestive tonic, Bone health
3	*Vaśiṣṭha*	*Arimedha* (Acacia ferruginea)	Oral hygiene, GERD
4	*Bhṛgu*	*Anantamūla* (Hemidesmus indicus)	Diuretic, aromatic, cooling
5	*Kaśyapa*	*Tulasi* (Ocimum sanctum)	Anti-microbial, Respiratory
6	*Bharadvāja*	*Apamārga* (Achyranthus aspera)	Anti-inflammatory, respiratory
7	*Viśwāmitra*	*Bilva* (Aegle marmelos)	Digestive healthcare
8	*Goutama*	*Dattūra* (Datura alba)	Anti-asthmatic, Antispasmodic
9	*Jamadagni*	*Dūrvā* (Cynodon dactylon)	Diabetes, Blood purification
10	*Marīci*	*Droṇapuṣpī* (Leucas aspera)	Antioxidant, Antimicrobial
11	*Aṅgirasa*	*Pūkam* (Areca catechu)	Bioavailability, Respiratory
12	*Nārada*	*Kamalam* (Nelumbo nucifera)	Heart tonic, Anti-anxiety
13	*Vālmīki*	*Devadaru* (Cedrus deodara)	Neurology, Respiratory health
14	*Vyāsa*	*Mallikā* (Jasminum indicum)	Aromatherapy, Nerve tonic

Table No. 4.12 Medicinal plants of popular sages - Ṛṣi-vana

4.5 Medicinal plant cultivation in community gardens

Historically community gardens were also part of the areas that were used to grow simple medicinal herbs, spices and also making various drug formulations and nutraceuticals for general healthcare in India. Some of these include growing popular medicinal plants and preparing fresh herbal formulations. The following table No. 4.13 gives the list of some of the common medicinal plants that were grown in community gardens and agroforests.

Formulation	Ingredients	Benefits
त्रिफला*	Dried - *Āmalakī* (Phylanthus emblica), *Haritakī* (Terminalia bellerica), *Bibhitakī* (Terminalia chebula)	Rasāyana, immunomodulation
त्रिकटुः*	Dried - *Śunṭhi* (Zingiber officinale), *Marīcam* (Piper nigrum), *Pippalī* (Piper longum)	Respiratory, Digestive
त्रिजातकम्	*Jātīpatri* (Myristica fragrans), *Elā* (Elettaria cardamomum), *Dāruśarkarā* (Cinnamomum verum)	Colds
पानकम्	*Āmalakī* (Phylanthus emblica), *Marīca* (Piper nigrum), *Śarkarā* (Saccharum officinarum), *Elā* (Elettaria cardamomum), *Karpūra* (Cinnamomum camphora)	Diuretic
पञ्चसारपानकम्	*Drākṣā* (Vitis Vinifera), *Madhukā* (Madhuca longifolia), *Gambharī* (Gmelina arborea), *Kharjūra* (Phoenix sylvestris), *Parūṣaka* (Grewia asiatica)	Cooling, Diuretic
वेशवारः	*Śunṭhi* (Zingiber officinale), *Marīcam* (Piper nigrum), *Pippalī* (Piper longum), *Dhānyaka* (Coriandrum sativum), *Ajāji* (Cuminum cyminum), *Dāḍima* (Punica granatum), *Pippalimūlam* (Piper chaba)	Stomach ailments
युगाद्युपसेचनम्	*Nimba-puṣpa* (Azadirachta indica), *Āmra* (Mangifera indica), *Lavaṇa* (Salt), *Guda*	Immune boost (before summer)

	(Saccharum officinarum)*, Kapittha* (*Feronia elephantum), Marīcam* (Piper nigrum)	*Important side-dish during new year.*
औषधकञ्चिः	*Punarnavā* (Boerhavia diffusa), *Tagara* (Valeriana wallichii), *Śūraṇa* (Amorphophallus paeoniifolius), *Ālukī* (Colocasia esculenta), *Trapuṣpā* (Cucumis maderaspatensis), *Pītakūṣmāṇḍa* (Cucurbita maxima), *Kūṣmāṇḍa* (Benincasa hispida), *Vṛścikāpatrī* (Tragia involucrata), *Liṅginī* (Diplocyclos palmatus), *Jīraka* (Cuminum cyminum).	Immune boost (before winter) *Leaves of 10 plants are cooked similar to greens and mixed with rice gruel*
पञ्चगोलः*	*Citrakā* (Plumbago rosea), *Śunṭhi* (Zingiber officinale), *Marīcam* (Piper nigrum), *Pippalī* (Piper longum), *Pippalimūlam* (Piper chaba)	Digestive
पञ्चपल्लवम्*	*Āmra* (Mangifera indica), *Jambū* (*Syzygium jambolanum*), *Kapittha* (Feronia limonia), *Bījapura* (Citrus medica), *Bilva* (Aegle marmelos)	Digestive, Hepato-protective
पञ्चवल्कलम्*	*Nyagrodha* (Ficus bengalensis) , *Udumbara* (Ficus glomerata) , *Aśvattha* (Ficus religiosa), *Plakṣa* (Ficus lecor), *Vetasa* (Salix caprea)	Reproductive healthcare
पञ्चतृणमूलम्*	*Kuśa* (Desmostachya bipinnata), *Darbhā* (Imperata cylindrica) (or) *Dūrvā* (Cynodon dactylon) , *Kaśā* (Saccharum spontaneum), *Śara* (Saccharum munja) and *Ikṣu* (Saccharum officinarum)	All kinds of microbial infections, Urinary healthcare
पञ्चतिक्तः*	*Patola* (Trichosanthes dioica) *, Nimba* (Azadirachta indica) *, Bhūnimba* (Andrographis paniculata) *, Rasnā* (Vanda roxburghii) *, Saptaparṇa* (Alstonia scholaris)	All kinds of stomach ailments, immune boost, microbial infections

Table No. 4.13 - Medicinal plants of community gardens

***** = These compositions /formulations are also used in *Vṛkṣāyurveda* as plant inputs for growth enhancers and/or pest repellents

4.6 Differences between *Kṛṣi-tantra* (Agriculture) and *Upavana-prakriyā* (Agroforestry) as per *Vṛkṣāyurveda*

The following table No. 4.14 highlights some of the distinct *Vṛkṣāyurveda* terminologies used across various *Vṛkṣāyurveda* texts to differentiate these two major divisions of cultivated plants, as discussed so far. Agriculture was also differentiated based on these two major divisions of plants. Many *Vṛkṣāyurveda* texts exclusively cater to the needs of Agroforestry for the cultivation of various plants.

Since time immemorial these two divisions were in practice due to the needs for the cultivation of various medicinal plants and spices – which are the largest traded commodities in the erstwhile 'Silk road' the Trans-Asian trade route, in which India was a major producer and trading economy for thousands of years.

Factors	*Kṛṣi-tantra*	*Upavana-prakriyā*
Agricultural Science of study	*kṛṣi-tantra* – (crop field) is the agricultural science dealing with the cultivation of food crops (food grains) and their management	*upavana-prakriyā* (agroforestry) – cultivation of various types of plants such as vegetable, fruits, flowers and medicinal herbs, and their management
Agricultural field type	*kṣetra/kedāra* – Crop field. For the cultivation of food grains (mainly consisting of 17 different annuals)	*upavana/kṣetravana/ārāma* – Agroforest. For the cultivation of Vegetables, fruits, medicinal plants and

		all other types of plants.
Land type	*anūpa-deśa* – Watery land. Land with plenty of water availability for irrigation (well irrigated field). In addition this land is also in plains for water holding capacity.	*sādhāraṇa-deśa/jāṅgala-deśa* – Ordinary land/ Arid land. Land with normal and/or less water availability for growing plants. Lands that are both in plain and sloppy areas.
Types of crops	*sasya-dhānyādi* – food grains and staples including pulses and legumes.	*śāka-phala-puṣpa-hayuṣa-drumādi* – Vegetables, Fruits, Flowers medicinal herbs and Trees
Botanical types	*oṣadhi* – annuals. The term *oṣadhi* has context sensitive meanings denoting i). the 'Plant' – the first life-form in Vedas ii) the 'Annual plant' – in certain places in Ayurveda iii) the 'medicinal herb' in Ayurveda and *Vṛkṣāyurveda*	*pādapa* - perennials and annuals. This term is a generic one classifying all plants.
Commercial categories	*annapānādi* – edible plants. Mainly concerned with food crops requiring special attention during cultivation, harvest and storage. This is a classification as per *Caraka-*	*udbhidādi* - botanical, meaning food, ornamental and all others; *virecanādi* - medicinal plants and herbs

	saṃhitā.	
Primary planting	*udvartana* - Springing up of crop in the seed bed – seedlings. Subsequently transplanting them in the crop field.	*sthāli ropaṇa* - Growing up of plant saplings in pots to subsequently planting them in the Agroforest /garden.
Planting cycle	*bījopti-cakra* - Sowing cycle, denoting the sowing of all gramineous crops and annuals	*bījotpatti-cakra* - Seeding cycle, denoting the planting of herbaceous and woody plants
Propagation	*bījāṅkura* - seedling	*kāṇḍāṅkura* - sapling
Growing	*āvāpana* – sowing	*āropaṇa* – planting
Trans-planting	*sasyāropa* – transplanting of seedlings	*viropaṇa* - transplanting of saplings
Irrigation	*niṣecana* – Controlled timely irrigation, including flood irrigation.	*Salila secana* - Watering as required
Harvest	*lavana* – cutting (harvest)	*lavaka/cayana* – plucking /collecting (harvest)
Threshing	*kaṇamardana* (threshing)	---
Drying of harvest	*āśoṣaṇa* - drying of grains	---
Dehusking	*avahanana* – de-husking	---

Table No. 4.14 Differences between *'Kṛṣi-tantra'* and *'Upavana-prakriyā'*

The subtle differences between Agriculture and Agroforestry are depicted in the Figure 4.2.

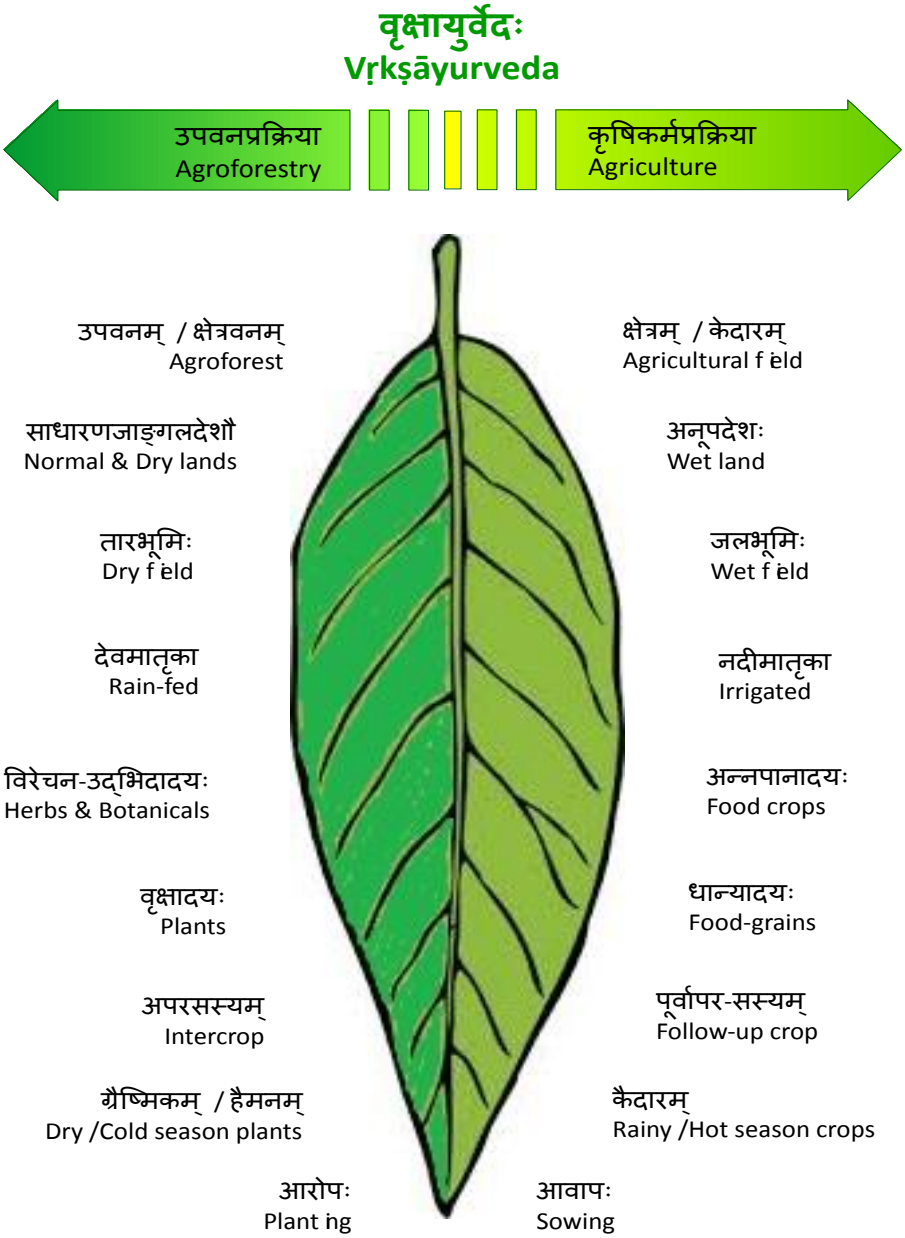

Figure No. 4.2 Agroforestry and Agriculture

4.7 Major divisions of Plants in *Vṛkṣāyurveda*

As discussed in this chapter previously, *Vṛkṣāyurveda* divides agriculture into two distinct divisions: cultivation of '*sasya*'(crops) and cultivation of '*vṛkṣa*' (all other plants). The first one, *sasya* deals with the aspects of various crops primarily annuals such as Rice, Wheat, Pulses, Lentils, Sugar-cane, Banana, Potatoes, etc.

The second one '*vṛkṣa*' (plants) deals with various plants both annuals and perennials and includes all kinds of plants from Trees to shrubs to creepers to medicinal plants which provide us vegetables, fruits, flowers, bark and roots. The following table No. 4.15 highlights the botanical characteristics of these two major divisions of plants (agricultural) as per *Vṛkṣāyurveda* and also based on the modern classification parameters.

Sasya - Crops	*Vṛkṣa* - Plants
Mono-culture agricultural field	Poly-culture agricultural land
Gramineous	Herbaceous & Woody plants
Self-pollination	Cross pollination
Harvest index (seed /grain)	All types of Biomass (seed, leaf, bark, flower, fruit, stem, resin and root) – *This is applicable for Medicinal plants*
Yield orientation	Overall growth /Efficacy orientation
High water needs	Low water needs
Water is held in the field through flood irrigation	Water is drained in the farm-land

Sasya - Crops	*Vṛkṣa* - Plants
Very low tolerance to biotic /abiotic stress – this need to be low to get higher yield	Moderate biotic /abiotic stress acceptable – Some degree of stress is elicited and which helps medicinal plants to increase their content of various phytochemicals, which are part of the active principle of the medicinal herb. This is applicable for Medicinal plants.
Glycophytes – Plants that grow in fertile and non-salty soil (plant classification based on soil type)	Mesophytes / Xerophytes – Plants that grow in all kinds of soils (plant classification based on soil type)

Table No. 4.15 – Botanical differences between *'sasya'* (food grain crops) and *'vṛkṣa'* (plants)

In addition to the Botanical differences described above, the following Figure No.4.3 details the differences between these two major classification of plants, i.e.: *'sasya'* (food grain crops) and *'vṛkṣa'* (plants) with respect to commercial, agricultural and morphological characteristics.

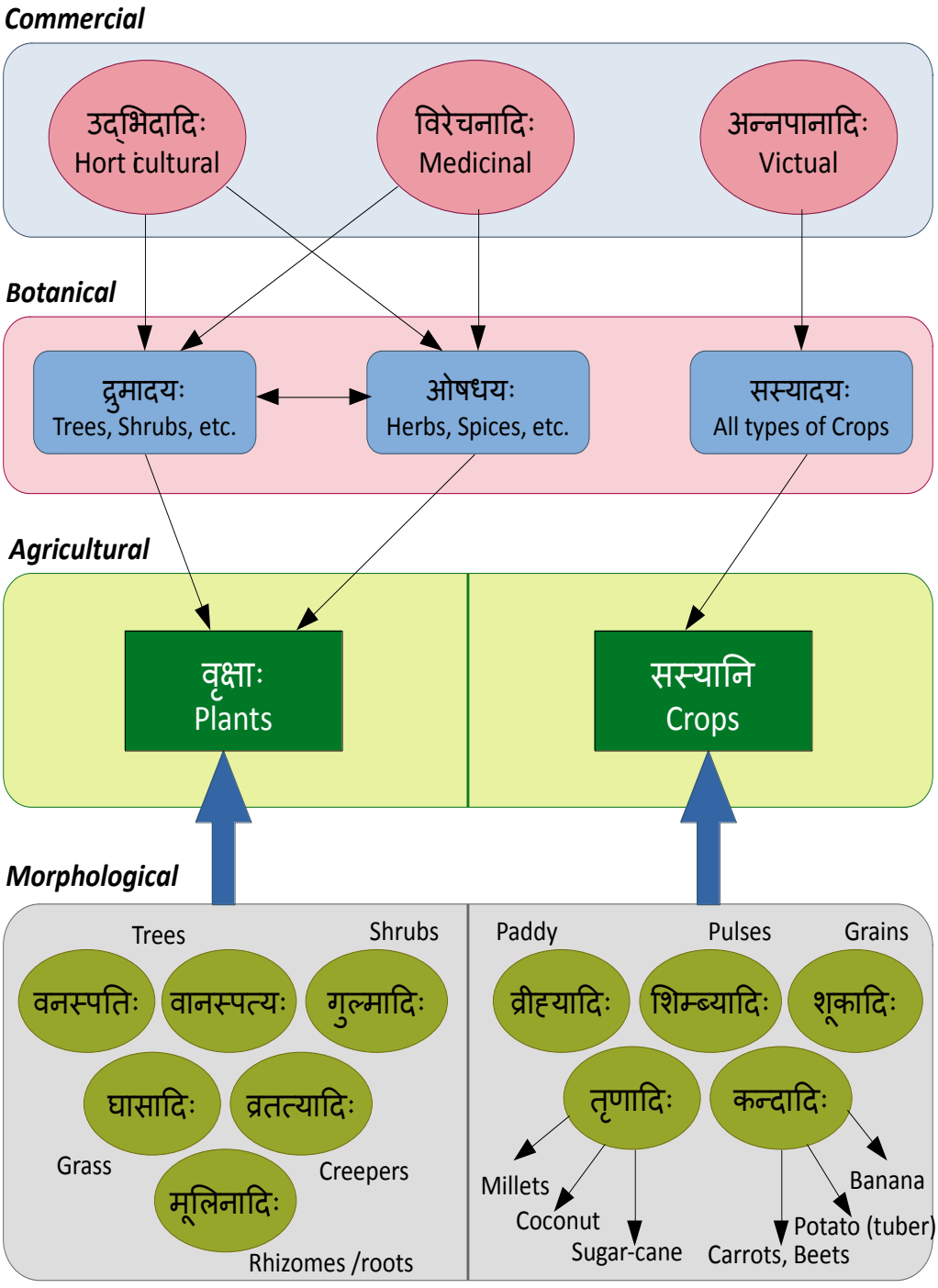

Figure No. 4.3: Plant classifications – '*Vṛkṣa*' and. '*Sasya*'

4.8 Medicinal plant cultivation and WHO, FAO-GACP standards

CAM (Complementary and Alternative Medicines), Nutraceutical and Herbal supplements gaining a lot of ground in the international healthcare scenario, where people are widely benefited with the plant based medicinal supplements. The European Food and Drug standards agencies, UN-FAO (United Nations Food and Agriculture Organization) and WHO (World Health Organization) jointly evolved various standards for safety of Herbal medicines and also prevention of herbal raw material toxicity in the new millennium. The standards such as GMP (Good Manufacturing Practices), GACP (Good Agricultural and Collection Practices), GSP (Good Storage Practices), etc. to name a few.

India being a signatory to WHO guidelines ratified the safety standards and thus ICMR (Indian Council of Medical Research), NMPB (National Medicinal Plants Board), and ICAR (Indian Council of Agricultural Research) have jointly evolved standards and guidelines for ensuring the safety and standardization of the Herbal medicines and Herbal raw material including Organic cultivation of Medicinal herbs.

ICAR (Indian Council of Agricultural Research) has produced training kits and material for the sustainable Cultivation, Collection and Storage of medicinal plants.

In essence, the three core safety issues that are identified by WHO, in context of the Herbal medicines and raw material are:

1. **Heavy metal toxicity** – Due to contamination of heavy metals such as Lead, Arsenic, Aluminum, etc. in herbal drugs

2. **Pesticide toxicity** – Due to contamination through the cultivation of Medicinal plants using chemical fertilizers and pesticides

3. **Microbial toxicity** – Due to contamination through the growth of Fungi, Mold, Bacteria, etc. while the herbal raw material storage

4.8.1 *Vṛkṣāyurveda* methods for Safe cultivation of MAP

1. **Heavy metal toxicity** - Contamination of heavy metals such as Lead, Arsenic, Aluminum, etc. are due to the poor manufacturing processes while producing herbal medicines. This is a serious issue with respect to finished herbal drugs and semi-finished herbal raw materials. To overcome these problems of contamination currently Ayurveda, Siddha and other herbal drug/raw material producers are adopting to GMP (Good Manufacturing Practices) – where the vessels are made with surgical grade stainless steel.

2. **Pesticide toxicity** - *Vṛkṣāyurveda* based cultivation methods are Natural/Organic and sustainable, where the inputs are made from locally available natural products. Therefore, are free from the contamination due to pesticide, insecticide, and other pest control chemicals

3. **Microbial toxicity** - *Vṛkṣāyurveda* medicinal plant specific storage and fumigation methods help in preventing contamination due to microbial growth in herbal raw material and also in semi-finished herbal products. Thus toxicity of microbes is prevented.

Vṛkṣāyurveda methods based cultivation of herbs and medicinal plants ensure 100% adherence to the guidelines of ICAR, WHO /FAO – GACP.

4.9 Relevance of *Vṛkṣāyurveda* in Medicinal efficacy

Ayurveda system of holistic human healthcare and the *Vṛkṣāyurveda* system of chronobiology based holistic agriculture follow the same philosophy, principles and practice in terms of *prakṛti, pañca mahā bhūta siddhānta, tridoṣa*, *rasapañcaka* and *dravya-guṇa-vijñāna*. All plants species and animal species and all other living beings have body and consciousness. All beings, human, animal and plants in principle have similar conditions of imbalances due to nutritional, seasonal and environmental factors. The principle of 'prevention rather than cure' is of prime importance in Ayurveda, and the same principle also applies to *Vṛkṣāyurveda* too.

Vṛkṣāyurveda and Ayurveda follow the same taxonomy and botanical classifications found in Ayurvedic materia-medica texts such as Dhanvantari-nighanṭu, Raja-nighanṭu, Bhāvaprakāśa-nighanṭu, etc., in addition to the plant nomenclatures match with the lexical classifications in *vanauṣadhi-varga* of Amarakośa. Thus *Vṛkṣāyurveda* and Ayurveda are indeed the twin systems of healthcare (food and medicine) that fall within the same branch of studies, i.e.: Life sciences.

Ayurveda and *Vṛkṣāyurveda* follow the same *Tridosha* related imbalance leading to diseases such as – Vāta *(Prāṇa),* Pitta *(Tejas)* and Kapha *(Ojas).* The diseases arising out of imbalance affects humans, plants and animals. *Vṛkṣāyurveda* proclaims the Biological interconnectedness and symbiotic nature of all life-forms

The Rasa pañcaka based pharmacological principles are applicable to all substances and thus the treatment for any plant (disease) imbalance can also be locally sourced and made using plant, mineral and animal products.

The antidotes and treatments, in principle are similar between Ayurveda and *Vṛkṣāyurveda.* Only the methods of therapeutic intervention differ. Similarly, the formulations are made from natural sources and differ only in complexities, between Ayurveda and *Vṛkṣāyurveda*. The cultivated medicinal plant through *Vṛkṣāyurveda* which becomes human medicine, shall be in its best medicinal efficacy with the 'active principle' component intact.

In addition to protection of medicinal efficacy of cultivated medicinal herbs, *Vṛkṣāyurveda* methods also ensure the produce being free from toxicity due to Chemical fertilizers and/or pesticides. *Vṛkṣāyurveda* based cultivation methods also include specific inputs according to each medicinal plant's *prakṛti* which are unlike general Organic inputs. These specifically ensure medicinal efficacy (*bhaiṣajya/vīrya*) of Ayurveda medicine in accordance with the Tridoṣa principle.

Chapter 5: *Vṛkṣāyurveda* based Cultivation of Medicinal Plants

Vṛkṣāyurveda based medicinal and aromatic plants (MAP) cultivation is an integral part of the '*upavana prakriyā*' – meaning Agroforestry or horticultural process, where medicinal plants were cultivated along with other horticultural crops. Right from Vedic times medicinal herbs were cultivated and been traded. The word '*auṣadhī*' has been used several times in '*Ṛg Veda*' and '*Atharva Veda*' to denote medicinal plants.

असंबाधं बध्यतो मानवानां यस्या उद्वतः प्रवतः समं बहु ।
नानावीर्या ओषधीर्या बिभर्ति पृथिवी नः प्रथतां राध्यतां नः[86] ॥

Salutations to mother earth, for the benefit of people who by offering hills, plains, fields and offer plants and medicinal herbs. She extends her bountiful offering and makes us healthy and happy.

द्वि संवत्सरस्य सस्यं पच्यते[87]।

'Two crops are cultivated in a year'

यवं ग्रीष्मा ओषधीः वर्षाभ्यो व्रीहिञ्शरदे ।
माषतिलौ हेमन्तशिशिराभ्याम्[88] ॥

'Barley in summer, herbs in rainy season, paddy in autumn, pulses and sesame during winter and cold seasons'

[86] Atharvaveda, Bhūsūkta, 12.2

[87] Taittirīya saṃhitā 5.1.7.3

[88] Taittirīya saṃhitā 7.2.10.2

In '*Atharva Veda*' and in Kautilya's '*Arthaśātra*' there are references with respect to cultivation of MAP. The medicinal plant terminologies such as '*auṣadhī*' (medicinal), '*bheṣajī*' (medicinal), '*phalinī*' (fruitful), aphalā (fruitless), puṣpiṇī (blossom) '*apushpā*' (blossomless), etc. are mentioned in '*Ṛg Veda* - 10.97.1-9' and also '*ābayu*' (Brassica juncea) , '*āsurī*' etc, are mentioned in 'kauśika sūtra'.

In Atharva Veda's many sūkta's (hymns) on agriculture such as '*kṛmi-sūkta*' (*Atharva Veda* – 4.37) medicinal plant cultivation is mentioned along with using various medicinal plants for Pest control and plant protection.

In '*Arthaśātra'* medicinal plant saplings were advised to be grown in pots and elevated platforms and then later transplanted into agroforests and gardens. Further, several *Vṛkṣāyurveda* texts such as '*Vṛkṣāyurveda of Surapāla*', '*Upavana vinoda*', '*Kāśśyapīya-kṛṣi-sūkti*' etc. mentions, '*upavanam*' (Agroforestry /garden) for growing medicinal plants. The famous *Vṛkṣāyurveda* text '*Kāśśyapīya-kṛṣi-sūkti*' has a separate section for the cultivation of vegetables, and also medicinal herbs, and aromatics.

5.1 Land Selection for Medicinal plant cultivation

Vṛkṣāyurveda, similar to the Ayurvedic texts 'caraka-saṃhitā' and 'suśruta-saṃhitā' and 'Arthaśāstra' mentions the three basic land types such as 'anūpa' (wet lands),'sādhāraṇa' (ordinary lands), and 'jāṅgala' (arid lands). However, *Vṛkṣāyurveda* extends these land types further based on crop types and water availability.

'*Amarakoṣa*' has the details of more than 10 types of lands based on soil type, color, water availability, etc. *Vṛkṣāyurveda* categorizes lands based on color, fertility of soil, irrigation and physical characteristics of soil. This way it was easy to relate a soil type to a crop/plant type. In addition, agricultural lands are also of 2 basic types. *'jalabhūmi'* (wet lands, low-land, food-grain crop lands), and '*tārabhūmi*' (dry lands, for all other plants).

Among these two types of agricultural fields, *'jalabhūmi'* is used only for growing primary food grains of 'annuals' type, such as rice, wheat, and barley. This land is also lower than the normal agricultural fields in the vicinity. This type of agriculture was known as '*nadī-mātṛkā-kṛṣi*'. The '*tārabhūmi*' is used for growing all other plants of both 'annuals' and 'perennials' which include medicinal and aromatic plants.

Among these three basic land types for medicinal plants '*sādhāraṇa*' (ordinary lands), and '*jāṅgala*' (arid lands) in addition to the agricultural /agroforestry fields of '*tārabhūmi*' types were used for MAP cultivation as most of the Ayurvedic herbs generally grow in forests and dry lands.

'Arthaśāstra' also mentions land types based on commercial aspects such as '*Kṣetram*' (human settlements – agricultural and dwelling) '*Vrajam*' (Pastoral lands for animal husbandry), '*Vanam*' (forest lands).

5.1.1 Land and soil types suitable for Medicinal plants cultivation

अल्पोदकद्रुमो यस्तु प्रवातः प्रचुरातपः ।
ज्ञेयः स जाङ्गले देशः स्वल्प-रोगतमोऽपि वा[89] ॥

[89], Carakasaṃhitā, Vimānasthāna - 3.47

Scarce water, less number of trees, windy and hot. It is to be known that these are the qualities of 'jāṅgala' type of land where the diseases are also less.

किञ्चिद् वृक्षको देशस्तथा साधारणः स्मृतः[90] ॥
मध्यः साधारणः स्मृतः ॥[91]

Where there are moderate number of trees and plants and water that land is 'sādhāraṇa' type and is in the middle (between wet-lands and dry-lands)

समा समासन्नजला हरिततरुतृणाङ्कुरा ।
तस्यां सर्वे यथास्थानं प्ररोहन्ति महीरुहाः ॥
न जाङ्गला न च अनूपा भूमिः साधारणा शुभा ।
तस्यां सर्वेऽपि वृक्षाः प्ररोहन्ति न संशयः ॥[92]

In normal balanced land not wetland where greens, trees, grasses, herbs and like this all kinds of plants grow in their respective places. Neither '*jāṇgala*' (arid land) nor '*anūpā*' (wet land) but normal land is best and in that all kinds of plants grow without any doubt.

श्वभ्र-शर्करा-अश्म-विषम-वल्मीक-श्मशान-आघातन-देवायतन-सिकताभिः अनुपहताम् अनूषराम् अभङ्गुराम् अदूरोदकां स्निग्धां प्ररोहवतीं स्थिरां समां कृष्णां गौरीं लोहितां वा भूमिं औषधार्थं परीक्षेत[93] ॥

Land without holes, lot of pebbles, anthills, burial grounds, sandy, infertility, and with water source nearby, undisturbed, medium, black /red /gray, etc. can be examined for growing medicinal crops

[90] Agnipurāṇa 280.15

[91] Agnipurāṇa 280.18

[92] Upavana vinoda 1.38 - 1.39

[93] Suśruta-saṃhitā

5.1.2 Inter-cropping of Medicinal plants

पाल्योलपानां गन्ध-भैषज्य-उशीर-हिर-बेर-पिण्डालुकानां यथा स्वं भूमिषु च स्थाल्याः च अनूपाः च ओषधीः स्थापयेत्[94] ॥ -,

Grassy patches, marginal furrows between any two rows of crops are suitable for the plantation of aromatics, medicinal herbs, rhizomes ('*uśīra*'), datura ('*hira*'), ginger, and *coleus root*s ('*pindáluka*') and the likes. Such medicinal herbs that grow in marshy grounds are to be grown not only in fields suitable for them, but also in pots ('*sthālī*')

त्रिविधः खलु देशः जाङ्गलः आनूपः साधारणश्चेति[95]

तत्र <u>जाङ्गलः</u>

पर्याकाश-भूयिष्ठः तरुभिः अपि च कदर-खदिर-रासना-अश्वकर्ण-धव-तिनिश-शल्लकी-साल-सोमवल्क-बदरी-तिन्दुक-अश्वत्थ-वट-आमलकीवन-गहनः अनेक-शमी-ककुभ-शिंशपा प्रायः स्थिर-शुष्क-पवन-बल-विधूयमान-प्रनृत्यत्-तरुण-विटपः प्रतत-मृगतृष्णि-कोप-गूढ-तनु-खर-परुष-सिकता-शर्करा-बहुलः लाव-तित्तिरि-चकोर-अनुचरित-भूमिभागः वातपित्तबहुलः स्थिर-कठिन-मनुष्यप्रायो ज्ञेयः

अथ <u>आनूपः</u>

हिन्ताल-तमाल-नारिकेल-कदलीवन-गहनः सरित् समुद्र-पर्यन्त-प्रायः शिशिर-पवन-बहुलः वञ्जुल-वानीर-उपशोभित-तीराभिः सरिद्भिः उपगत-भूमिभागः क्षितिधर-निकुञ्ज-उपशोभितः मन्द-पवन- अनुवीजित-क्षितिरुह-गहनः अनेक-वन-राजी-पुष्पितवन-गहन-भूमिभागः स्निग्ध-तरु-प्रतान-उपगूढः हंस-चक्रवाक-बलाका-नन्दीमुख-पुण्डरीक-कादम्ब-मद्गु-भृङ्गराज-शतपत्र-मत्त-कोकिल-अनुनादित-तरु-विटपः सुकुमार-पुरुषः पवन-कफप्रायो ज्ञेयः

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[94] Arthaśāstra 2.24.31

[95] Caraka-saṃhita, Kalpasthāna, 1.8

साधारणः

अनयोः एव द्वयोः देशयोः वीरुद्-वनस्पति-वानस्पत्य-शकुनि-मृग-गणयुतः स्थिर-सुकुमार-बलवर्ण-संहनन-उपपन्न-साधारण-गुणयुक्त-पुरुषः साधारणो ज्ञेयः ॥

The above passage from the Ayurvedic cannon '*Caraka*-saṃhitā' in the book of '*Kalpasthāna*' (book of formulations) describes in the first chapter, passage 8, the details of the basic three types of land and the general and medicinal flora found in these three land categories.

It is evident from this passage that the '*anūpa-deśa*' (wetland) is suitable for growing herbs that grow only in wetlands. It is to be understood that over 70% of the Ayurvedic herbs don't grow in this type of lands which are more suitable for food grain crops, banana, sugarcane and other sweet vegetables and fruits. The rest of the two land types are most suitable for the cultivation of medicinal plants and in addition require lesser water to grow.

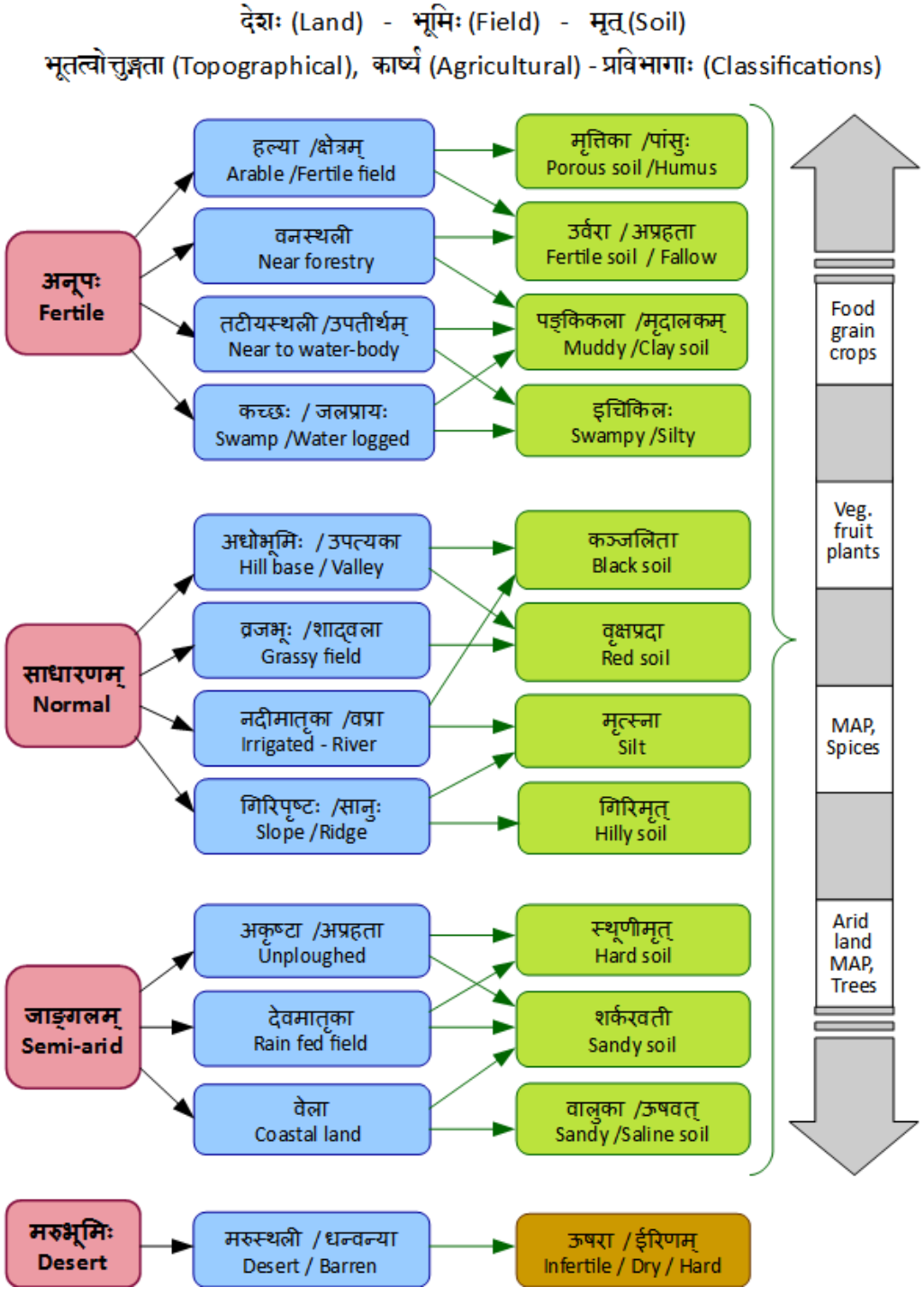

Figure No. 5.1 Land and Soil classifications

5.2 Soil management

Vṛkṣāyurveda provides in-numerous methods for soil management including management of soil fertility, soil humus, soil correction and types of soils and medicinal plant specific soil selection.

जाङ्गलानूपसामान्यस्वभावात् त्रिविधा धरा ।
रसैश्व षड्भिः सा भिन्ना ज्ञेयास्तद्वर्णतो रसाः[96] ॥

Land by nature is of three types dry, wet and ordinary. The soil in such lands are distinguished on the basis of six types of taste (qualities), which are determined by the color of the soil.

मलिना पाण्डुरा भूमिःश्यामला धवला अरुणा ।
पीता मिष्ट-आम्ल-लवण-कटु-तिक्त-कषायिकाः [97]॥

Soil is of six colors such as dark gray, pallid, black, white, red and yellow. Correspondingly the tastes of these soils are sweet, sour, saline, bitter, pungent and astringent.

5.2.1 Soil fertility

In ancient India across the entire subcontinent there were 3 crops cycles in a year. However, the cyclical monsoons were giving rains only for a period of three to five months in a calendar year. Therefore, except agricultural lands that are near to the river banks and those which have irrigation canals, the rest of the agricultural lands were used to produce horticultural crops, medicinal plants, spices and aromatics for a period of 8 to 9 months in a year.

[96] Viśvavallabha 3.1

[97] Viśvavallabha 3.2

Except the first crop or the primary food crop which was sown during rainy season, rest of the crops were of non-food grain types. Due to the cultivation of more than two crops in a year, soil conditions deteriorate and thus, replenishing soil fertility was of prime importance.

Soil and moisture conservation, soil organic matter, soil permeability were taken care through crop rotations[98], poly-culture, inter-cropping and alley cropping methods.

5.2.2 Green manure & Soil humus

Soil humus management methods can be found in many *Vṛkṣāyurveda* texts. In '*Bṛhatsaṃhitā*' and '*Upavana vinoda*', green manure as a soil input was recommended prior to the first crop by first planting a leguminous crop or sesame and plough and crushing it as a manure. Various *Vṛkṣāyurveda* texts have also mentioned Cow-dung manure and /or farmyard manure before second and third crop. Plant specific soil selection and management was also mentioned in '*Vṛkṣāyurveda'.*

मृद्वी भूः सर्ववृक्षाणां हिता तस्यां तिलान् वपेत् ।
पुष्पितांस्तांश्च मृद्नीयात् कर्मैतत् प्रथमं भुवः [99]॥

Soft earth is good for all trees. On such land, sesame should be grown first. Once they have flowered, the sesame plants must be ploughed under the soil. This is the first treatment that must be done to improve soil quality.

[98] Aiyer A.K., Yegna Narayan, Ag. Al. Ar. Ved. India, Page 17

[99] Bṛhatsaṃhitā – 55.2

उप्तं पुष्पचयाकीर्णतिलमाषाद्यवाहिते ।
भूप्रदेशे समे रम्ये वृक्षानारोपयेत्वपेत्[100] ॥

In a land which is flat, and plants like '*tila*' and *māṣā,* were sown and they are ploughed to ground after blooming, plant the seeds of various plants.

5.2.3 Soil correction

The *Vṛkṣāyurveda* text *'Upavana vinoda'* provides us many methods for Bio-amelioration (soil regeneration) – Leaf extract of '*Agati*' and '*Arjuna*' - both these plants along with Cow products are good for Bio-amelioration meaning correction of high Acidity and Alkalinity in soil.

अरिष्टाशोकपुन्नागशिरीशाः सप्रियङ्गवः ।
मङ्गल्याः पूर्वम् आरामे रोपणीया गृहेषु वा[101] ॥

Ariṣṭa, aśoka, punnāga, śirīṣa and *priyaṅgu* are auspicious (medicinal) plants and must be grown first in Agroforests and home gardens.

5.2.4 Traditional soil types and suitable Ayurvedic medicinal herbs

Soil type	Suitable Medicinal plants
Color = Dark gray color Prakṛti = Pṛthvī and Jala Rasa = Madhura (Sweet) Consistency = Silty /Peaty	'Vamana' (Purgative) herbs like haritaki, bibhitaki, and 'Dīpana' (Emetic) herbs like Castor, Vidanga, etc.
Color = Red /Brown Prakṛti = Pṛthvī and Agni Rasa = Amla (Sour) Consistency = Alluvial soil	'Rasayana' (immunomodulatorory) herbs like guduchi, ashvagandha, shatavari, etc. 'Pacana' herbs like Haridra, Shunthi,

[100] Surapāla vṛkṣāyurveda 1.63

[101] Bṛhatsaṃhitā 55.3

Color = White Prakṛti = Vāyu and Ākāśa Rasa = Tikta (Bitter) Consistency = Sandy	Aus paddy, 'lekhana' herbs – tulasi, kalamegha, sarshapa (mustard), Aloe vera,
Color = Yellow Prakṛti = Pṛthvī and Vāyu = Rasa = Kaśāya (Astringent) Consistency = Clay	Paddy, Jute and fodder, 'bṛhmaṇa' (anabolic) type of herbs
Color = Black Prakṛti = Jala and Agni Rasa = Lavaṇa (Saline) Consistency = Arid and dry	Dryland herbs – guggulu, hingu, arjuna, and 'laṅgaṇa' (catabolic) type of herbs
Color = Grey /Brown Prakṛti = Agni and Vāyu Rasa = Kaṭu (Pungent) Consistency = Loamy	'Pacana' (inducing digestive fire) type of herbs

Table No. 5.1 Traditional soil types and suitable medicinal plants

The above table No. 5.1 above gives indicative guidelines with respect to the overall connection between soil types and the medicinal plants. However, through regular cultivation in a particular geography a medicinal plant's specific needs of conducive soil, water and climatic conditions can be completely established. More over with hybridization and domestication of all types of plants including medicinal herbs for many years, many of the plants would have adopted to certain non-native land and soil conditions.

5.3 Water management

Water management is an important part of all *Vṛkṣāyurveda* texts and practices. Water sources such as monsoon rains, ground water identification and irrigation canals were described in most of the *Vṛkṣāyurveda* texts.

जलमेकविधं सर्वं पतत्यैन्द्रं नभस्तलात् ।
तत् पतत् पतितं चैव देशकालावपेक्षते ॥
खात् पतत् सोम-वायु-अर्कैः स्पृष्टं कालानुवर्तिभिः ।
शीतोष्णस्निग्धरूक्षाद्यैः यथा आसन्नं महीगुणैः[102] ॥

Water is initially only one type which fall from the sky, acquires different qualities based on Sun-light, winds, seasons, heat /cold, moisture and finally based on the land it falls and stays /flows.

5.3.1 Rains, rain patterns and rain predictions

वृष्टिमूला कृषिः सर्वाः वृष्टिमूलं च जीवनम् ।
तस्मादादौ प्रयत्नेन वृष्टिज्ञानम् समाचरेत् [103]॥

All agricultural activities depend on water and the whole life depends on water and therefore first with effort understand the knowledge of rains and rain patterns (agro-meteorology).

In olden day there were region specific *'kṛṣi-pañcāṅga'* (agricultural almanac) for predicting monsoons and weather conditions. Knowledge of rainfall is gained through various celestial positions of sun, moon and other planets. Weather patterns such as wind speed, direction and moisture also helps in meteorological estimations for rainfall. Cloud types such as '*āvarta*', '*samvarta*', '*puṣkara*' and '*droṇa*' also help in rainfall predictions. The five-year cycle and seven year cycles of rain-fall, floods, droughts, earthquakes and other natural phenomenon were described in *'kṛṣi-pañcāṅga'* according to geographical locations. Migration and movement of birds and insects were also used for prediction of rains and droughts.

[102] Carakasaṃhitā, Sūtrasthāna, 27.196 - 197

[103] Kṛṣi-parāśara 1.10

Rain pattern understanding was part of education /learning for all agriculturalists. This knowledge of observation and predictions of rain are made based on natural phenomenon and celestial observations which are part of predictive astrology ('*phalita-jyotiṣa*') derived and calculated based '*pañcāṅga*'

Rain pattern - Observational methods

- Air flow patterns and wind speeds
- Atmospheric changes
- Changes in the behavior of birds and animals
- Insect migration
- New leaf formation in plants
- Formation of clouds

Rain predictions based on Astrological factors

- Computation of planetary positions, movements and conjunctions of stars and planets
- Study of solar ingress and particular date of months
- Study of cycle of 27 '*Nakṣatra*' and moon alignment
- '*Horaśāstra*' (horoscope)

Majority of the cultivation in the olden days in India were based on monsoon rains and rain water storage in various water bodies. The agriculture and agroforestry based cultivation of non food-grain crops were primarily done in normal and semi-arid lands and fields. These kind of cultivation was known as '*devamātṛkā kṛṣi*'

5.3.2 'Dakārgala' - Ground water identification

धर्म्यं यशस्यं च वदाम्यतो वै दकार्गलं येन जलोपलब्धिः ।
पुंसां यथा अङ्गेषु शिरास्तथैव क्षितावपि प्रोन्नतनिम्नसंस्थाः[104] ॥

Order, fame follows the person who identifies groundwater and manages it well. How the blood-flows in the body similarly water flows life on Earth.

'*Dakārgala*' or '*bhūgarbha-jalajñānaśāstra*' is the science of ground water identification. Several methods such as specific trees, anthills, grass patches, soil conditions, etc. denote the availability of ground water in specific regions. Varāha Mihira has elaborated this unique science in his works '*Bṛhatsaṃhitā*' and '*Bhūgarbhajalajñānaśāstram*'. '*Vāpī*' (large tank), '*kūpa*' (well), '*tadāga*' (lake /pond), '*setu*' (reservoir) were constructed based on the methods of '*dakārgala*'. '*Setu*' meaning reservoir (or) water storage facility is of 2 types. *'sahodaka setu'* which were for bringing out and storing the ground water through natural springs. '*aharyodaka setu*' – these reservoirs and dams were constructed to store excess water from monsoon rains and overflowing rivers.

'Kāśyapīya-kṛṣi-sūkti' has a dedicated chapter on construction of four types of water bodies and they are '*kūpa*' (well) , '*vāpī* '(tank), '*hrada'* (lake/pond), '*dīrghikā*' (large reservoir).

[104] Bhūgarbha-jalajñāna-śāstram 1.1

5.4 Irrigation and water treatment

'*Nadī mātṛkā*' (well irrigated) agricultural fields, have in their vicinity a large water body of either a river or a huge lake. The irrigation canals called as '*kulyā*' were constructed for the flow of water to the fields.

Many types of irrigation canals and water bodies were constructed and the following Table No. 5.2 lists the popular ones that were in vogue in ancient times in India.

1	सरित्	River
2	नदी	Large river
3	जलाशयः, जयः, दीर्घिका	Big /long Reservoir
4	गुञ्जालिका	Small reservoir
5	जलबन्धः, जलाधारः	Dam / reservoir
6	सेतुः	Bridge /Reservoir
7	द्वारिबन्धः	Check dam (small dam)
8	सरः (सरस्)	Large lake
9	देवसरः	Naturally formed lake
10	सरोवरः	Lake
11	तडागः	Small Lake
12	ह्रदः	Deep /Large pond
13	वापी, पाली	Pond /Large well /Step well
14	कूपः, दुन्दुभिः, अन्धुः, प्रहिः, नन्दः	Well
15	पल्वलम्	Small pond
16	खनित्रिमा	Water storage pit (khadin or dhora)
17	उदकमार्गः	Water way
18	प्रणाली	Water way (small)
19	हरणिः, परिखा	Water channel / Trench

20	नीका, मातृका	Irrigation channel
21	कुल्या	Canal
22	उपकुल्या	Water canal in-let into the field
23	निर्कुल्या, तोयनिर्गमः	Water canal out-let from the field
24	आहावः, निपानम्	Well canal /trough
25	बन्ध्यः	Embankment in water body
26	खेयः	Water drain way
27	नैर्वाहिकम्	Sluice
28	सत्त्रम्	Tank
29	पुष्करः	Temple tank
30	कासारम् , सरसी	Pool
31	दीर्घिका, वावः	Step well
32	वेशन्तः	Small pool
33	खातः	Moat / Ditch
34	जलप्रबन्धनम्	Water management
35	द्वारिबन्धः	Damming a natural catchment – reservoir
36	तोयदानम्	Irrigation
37	पुलिनम्	Sand bank / River bank

Table No.5.2 Various types of water bodies and water management during ancient times in India

5.4.1 Water Treatment:

Water treatment is an important activity in irrigation in agricultural practices in India. This is to improve the water quality and also to reduce salinity, turbidity, hardness and other undesirable qualities, herbal decoctions and mixtures were used in the water reservoirs.

अञ्जन-मुस्त-उशीरैः सराजकोशातक-आमलकचूर्णैः ।
कतकफल-समायुक्तेः योगः कूपे प्रदातव्यः ॥

कलुषं कटुकं विरसं लवणं सलिलं यदि वा अशुभगन्धि भवेत् ।
तदनेन भवत्यमलं सुरसं सुसुगंधि गुणैरपरैश्च युतम्[105] ॥

Powdered mixture of '*añjana*', '*musta*', '*uśīra*', '*rājakośātaka*', '*āmalaka*' and '*katakaphala*' has to be applied to a well /pond to purify the waters. Water that is dirty, sour, salty, off taste or foul smelling shall be made clean, tasty and fragrant by this mixture and it will also acquire other desirable qualities for drinking and agriculture.

According to '*Rājanighanṭu*', the Ayurvedic meteria medica text the bark extract powder of the plant '*vātāma*' (Terminalia catappa) can be used for cleaning water bodies such as ponds and wells.

5.5 QPM (Quality planting material) – seeds, saplings, etc. and propagation

Quality planting materials including seeds, seedlings, saplings, stems and all other propagation materials are given below as described in *Vṛkṣāyurveda* texts

5.5.1 Propagation:

Vṛkṣāyurveda describes different types of propagation methods for different types of plants. The propagation methods include '*bījabīja*' (propagation through seeds) for small plants, '*skandabīja*' (propagation through stem cuttings) for trees, '*aṅkuraja*' (propagation through seedlings) for food grain crops, '*saunarudhaja*' (propagation through saplings) for various plants, etc. Seed beds were also recommended for growing plants.

[105] Surapāla vṛkṣāyurveda 1.299 - 1.300

सम्यक्कृष्टे समे क्षेत्रे माषानुप्त्वा तिलांस्तथा ।
सुनिष्पन्नान् वपनयेत् तत्र बीजोप्तिः इष्यते[106] ॥

Sow '*māṣā*' and '*tilā*' in a land that is even and well ploughed field. After they have grown well, crush them to the ground (Green manure) and plant the other herbs on that land.

एते द्रुमाः काण्डरोप्याः गोमयेन प्रलेपिताः ।
मूलोच्छेदे अथवा स्कन्दे रोपणीयाः परं ततः[107] ॥

These plants need to be planted with stems besmeared with cow-dung. Others to be planted either by root cuttings or branch cuttings.

द्राक्षा-अतिमुक्तको जम्बू-बीजपूरक-दाडिमाः ।
कदली-बहुल-अशोकाः काण्डरोप्याश्च वापयेत्[108] ॥

Plants like drākṣā, atimuktaka, bījapūraka, dāḍima, kadalī, bahula, aśoka, etc. need to be propagated by stem plantings.

उप्तिः मरुवकः च अत्र तथा दमनकस्य च ।
कल्पित-अल्पक-केदारे कीर्तिता कुंकुमस्य च [109]॥

Sowing '*maruvaka*', '*damanaka*', and '*kunkuma*', etc. in a raised seed-bed is considered to be ideal practice.

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[106] Upavana vinoda 1.50

[107] Bṛhatsaṃhitā, Vṛkṣāyūrvedādhyāya, 55.5

[108] Bṛhatsaṃhitā, Kāśyapa-vṛtti, 55.5 - 6

[109] Surapāla vṛkṣāyurveda 1.71

5.5.2 Seed treatment

Vṛkṣāyurveda recommends using seed fortification and germination inducing substances for seed treatment. Fortification techniques such as (1) soaking of seeds in special solutions which were mixed with cow urine, and '*kuṇapa-jala*', milk and honey mixture helped in strengthening the seeds against various diseases. (2) Besmearing seeds with clay, cow-dung, '*Pañcagavya*' was done to make seed balls to improve germination of seeds. (3) Drying of seeds in sunlight on three consecutive new moon days and also in mist ('tuṣārapāyanam') during full moon nights (4) Fumigation and drying of seeds using smoke of '*vidaṅga*' seed powder.

बीजस्य दोषादकृतोपचारात्मिथ्योपचारादपचारितो वा ।
क्रुद्धाः प्रकुर्व्वन्ति समीरणाद्या वन्ध्यान शेषान वनीरुहांश्च[110] ॥

Bad seeds, lack of proper care, or administering wrong treatments would severely alter the humors of the plant body, and this would make all plants barren (none of the trees will bear fruit).

पयसि निषिक्तं बीजं गोमयपरिमर्द्दितं विशोष्य ततः ।
माक्षिकविडंगचूर्णैः बहुशो मृदितं प्रजायते नूनम्[111] ॥

Seeds that are sprinkled with milk, rubbed with cow-dung, dried and profusely besmeared with '*makṣikā*' (honey) and '*vidaṅga*' powder germinate and grow well.

[110] Surapāla vṛkṣāyurveda 1.180

[111] Surapāla vṛkṣāyurveda 1.54

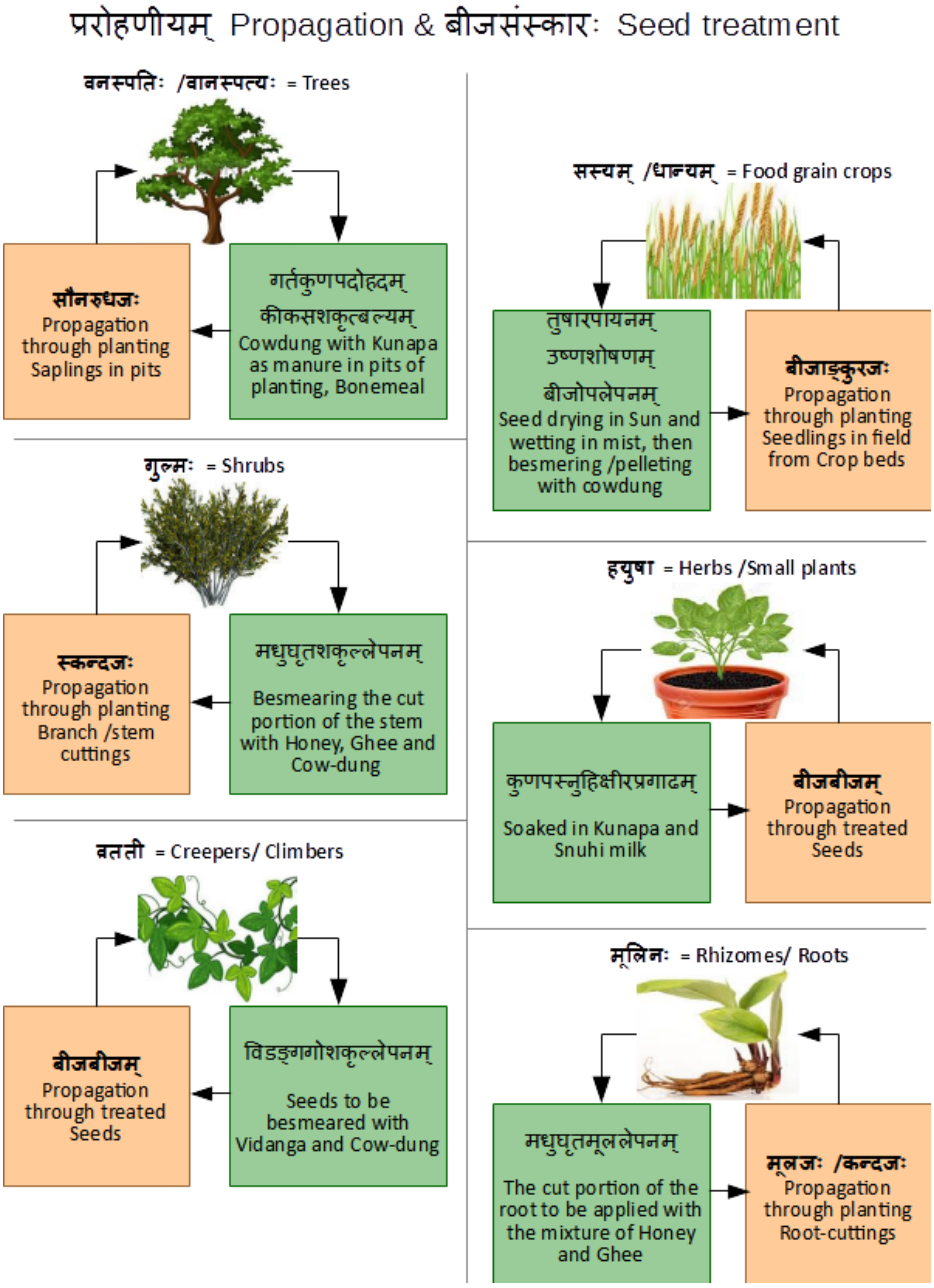

Figure 5.2: Propagation, seed treatment and Planting

5.5.3 Cultivation and Plant Growth

Vṛkṣāyurveda advises food grain seeds are germinated in seed beds. The crops seedlings are subsequently transplanted in marshy agricultural fields.

For Pulses and legumes seeds are advised to be scattered in the agricultural field. For other plants including medicinal herbs, saplings are advised to grown first in small pots and then they are planted in gardens and Agroforest. Trees are propagated through stem cuttings and saplings.

Before planting saplings and stem cuttings in gardens and agroforests, the sapling pits that are prepared for planting are first burnt in fire, fumigated and are manured with '*kuṇapajala*' and cow-dung composts.

Vṛkṣāyurveda texts recommend using ample amount of green manure, composts, farm-yard manure and many other soil addenda for improving soil fertility as well as growth of plants to ensure good yields. In addition, Sun, heat and frost control shading thatches were also recommended during the early stages of plant growth. Mulching is advised to prevent both pest attack on the roots and also to maintain soil moisture.

Plant nutrition and plant protection are the key focus of many *Vṛkṣāyurveda* texts apart from various seed treatment methods. Agro-meteorology methods to predict rains are essential for determining watering and irrigation needs of plants. Methods given in '*Kṛṣi parāśara*' and '*Bṛhatsaṃhitā*' were used for rain prediction and water management during plant growth cycles.

5.5.4 Medicinal plant forests and agroforests

जनोपकारकान् अन्यान् पिप्पली प्रङ्खान् अपि ।
नानाविधाः च औषधीन् लताः च प्राणवर्धकाः ॥

वर्धयेयुः विशेषेण तत्तत् क्षेत्रानुरूपतः ।
यथाकालं यथा आचारं पूर्वसूर्युपदेशतः[112] ॥

Medicinal plants which are beneficial to the people, such as '*pippalī*' and various other medicinal herbs and life promoting creepers should be grown according to the season based on the advice of the experts.

अन्याश्च ओषधि-वल्लीः च नलदान् अपि वर्धयेत् ।
कुशान् काशांश्च विविधान् तुलसी-बिल्वकादीन् ॥
कुसुमानि च पूजार्हानि अनेकानि च भूमिपः ।
काललभ्यानि गन्धाढ्यान् अपि सर्वत्र वर्धयेत् [113]॥

Other medicinal plants such as cinnamon, kuśa, tulasī, bilva, fragrant flowers used for worship and herbs which are seasonal and also 'gandhāḍhya' aromatics, are to be cultivated which are beneficial to people.

The *Vṛkṣāyurveda* text '*kāśyapīya-kṛṣi-sūkti*'[114], recommends the Kings to construct medicinal and community forests near to human settlements. These agroforests should be maintained for the sake of happiness and healthcare on all fronts with the help of farmers, citizens and soldiers. These forests should include lakes, wells and irrigation canals.

5.6 Plant nutrition

Plant specific nutrition management is the most important aspect of '*Vṛkṣāyurveda*'.. Medicinal plants were grown supported by specific nutritional substances that are '*sātmya*' (compatible /appropriate) to their

[112] Kāśyapīya-kṛṣi-sūkti 2.74-75

[113] Kāśyapīya-kṛṣi-sūkti 2.135-136

[114] Kāśyapīya-kṛṣi-sūkti 2.143b – 2.157 = 26 verses

'*tridoṣa-prakṛti*' (pheno-type) and also based on seasonal, geographical, topographical conditions.

Several *Vṛkṣāyurveda* texts mention plant nutritional substances such as '*kuṇapa-jala*', *'pañja-gavya'* and '*sasya-gavya*'. These three substances are made with Cow-dung and Cow-urine as primary components and are primarily in liquid form. *Vṛkṣāyurveda* texts also recommends using composts of cow-dung, goat excreta etc., along with plant specific botanical supplements.

'*Udbhijjabalyam*' is the term which refers to plant growth stimulants and botanical supplements which are used for seed fortification to plant growth enhancement. Fortification of seeds and saplings using specific herbs and spices along with jaggery, honey, and powders of legumes were recommended in *Vṛkṣāyurveda* texts and many of these are also practiced in tribal agricultural practices and documented as Indian agricultural ITK (Indigenous Technical Knowledge) and are part of 'Applied-*Vṛkṣāyurveda'*

In Tamil Nadu, Dr. Natarajan (2003) popularized the use of '*pañcagavya*' (cow dung, urine, milk, curd, and ghee). '*pañcagavya*' has been actually prescribed in Ayurvedic texts for curing many human aliments. '*pañcagavya*' has been mentioned in '*kāśyapīya-kṛṣi-sūkti*' for '*bhūmi-pūja*' (worship) and 'bhūmi- śuddhīkaraṇa' (cleansing the land). The proportion of cow-gung and cow-urine mixed in '*pañcagavya*' for human consumption is of minuscule quantity. Mixing medicines with very small quantities of cow urine is practiced in Ayurveda for improving efficacy of some medicines.

The '*pañcagavya*' that's being used in organic agriculture has high amount of cow-gung and cow-urine. In addition this mixture of five cow products are also being fermented for a fortnight before applying to plants. Therefore, in essence, the agricultural '*pañcagavya*' being a mixture of cow products and also being scientifically proven can be considered as an effective plant nutritional substance on par with other *Vṛkṣāyurveda* based plant nutritional substances.

5.6.1 Kuṇapa-jala

Vṛkṣāyurveda texts describe the importance of the generic plant nutrition substance '*kuṇapa-jala*' for the healthy growth of plants. '*Kuṇapa-jala'* contains high amount of organic nitrogen and also other critical plant nutrition such as 'NPK' (Nitrogen, Phosphorus and Potassium)

धूपो घृतस्य समृदो यववारिसेको नित्यं च दुग्धसलिलैः कुणपाम्बुभिर्वा ।
लेपो विडङ्गतिलकल्ककृतः शिशूनां वृद्धिं करोति परमां खलु भूरुहाणाम्[115] ॥

Fumigation of saplings, besmearing of the seeds with ghee and mud, sprinkling of barley-water every day, sprinkling with milk-water and '*kuṇapa-jala*' *and* anointment with the sediment of ground '*vidaṅga'* and '*tila'* are good for initial plant growth.

कुणपांबु शकृन्मांसातीनि द्रव्याणि सेचने ।
मांसकिण्वाश्रिताम्बुभिः कुणपांबुभिः विमिश्रितैः ॥
भवन्ति फलपुष्पाढ्याः सर्वा भूरुहजातयः[116] ॥

Plants must be sprinkled with substances like '*kuṇapa-jala*', cow dung and meat. '*Kuṇapa-jala*' too must be mixed with meat and *'kiṇva-jala'*

[115] Upavana vinoda 1.166

[116] Surapāla vṛkṣāyurveda 1.113-114

(fermented substance water) before use. Application of these results in all plants will be producing abundance of flowers and fruits

In Surapāla *Vṛkṣāyurveda*, the following verses (Sadhale, 1996), highlight the importance of '*kuṇapa-jala*'

Surapāla *Vṛkṣāyurveda* Verse 102-103: As per availability, the fat, marrow, and the flesh of fish, the ram, the goat, and other horned animals should be collected and mixed with water. These should be boiled after mixing with water, and the mixture should be stored in an oiled pot after adding sufficient quantity of husk. This solution should be stored underground and after fermentation this solution is called '*kuṇapa'*.

Surapāla *Vṛkṣāyurveda* Verse 106. This '*kuṇapa'* is highly nourishing for all types of plants. This is as stated by the ancient sages and I (Surapāla) repeat in here after verifying the same.

'Viśvavallabha', the *Vṛkṣāyurveda* text describes many plant based Bio-inoculants added with Cow products to create '*sasya-gavya*' (plant ingredients mixed with cow products). There are many '*sasya-gavya*' substances which can be prepared by the farmers depending on the type medicinal plant and also seasons.

'*kuṇapa-jala*', '*sasya-gavya*' along with '*pañcagavya*' are the most suitable for the cultivation of Medicinal plants as they are primarily prepared and available in liquid form and thus are easy to apply to Medicinal plants. Application of these substances can be done to roots with buried pots near the plants and also in foliage.

5.6.2 Cow products including Cow dung

Cow dung has been in use for agricultural input for both soil management as well as plant growth stimulant since Vedic times. Both in *Ṛgveda* [117] and in *Atharvaveda* Cow dung's usage as manure and plant growth enhancer is recorded.

Ayurveda establishes that, 'gomaya' (cow-dung) is used as an excellent bio-remediation method. Thus, utilizing freely available cow dung as slurry or after composting in rural areas, is a cheap and effective measure to bio-remediate the harmful pollutants. Cow-dung usage as a manure could serve as a relevant model ecosystem to bio-remediate using the fungi and bacteria present in Cow-dung such as coprophilous basidiomycetes and Cyathus stercoreus, which can biodegrade toxic pharmaceutical /chemical substances such as enrofloxacin.[118]

Cow dung contains undigested plant fibers, epithelial cells, pigments and salts, rich in organic nitrogen, phosphorus, potassium and many other micro-nutrients. It also contains bovine intestinal bacteria and mucous according to the agricultural scientist Dr. Y.L. Nene (AAHF). Cow-dung contains water about 80% and solid matter about 20%. The solid matter includes minerals, ash and organic manure.

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[117] Ṛgveda 2.8.3 and Atharvaveda 3.14.3

[118] *Gurpreet Kaur Randhawa and Jagdev Singh Kullar, "Bio-remediation of Pharmaceuticals, Pesticides, and Petrochemicals with Gomeya /Cow Dung" ISRN Pharmacology. 2011*

Soil fertility research from 1920 till 2015 - Prof. William Albrecht of Missouri University to the latest Environmental Biologist Dr. Allan Savoury reports confirm that cattle excreta can remedy the soil and make it fertile.

Cow's milk has been used as plant tonic by farmers since the Vedic times in India. According to Dr. Y.L. Nene milk is an excellent sticker and spreader. Milk is a good medium for Saprophytic bacteria and is also virus inhibitor. In addition cow's milk can also be used for seed treatment and preparation of '*Udbhijjabalyam*' (plant tonic) such as '*pañcagavya*'.

Several microbiological studies have confirmed that among all the species cows have the highest disease fighting and resisting genetic structure. Bacteriophages have been identified in bovine have the capacity to replace various antibiotic substances for disease control. According to Prof. Azad Kaushik of Guelph University, these bovine antibodies can also effectively destroy antibiotic resistant bacteria. Bovine products has been used in agriculture in India since millennia for soil improvement, plant nutrition and pest and disease control.

Ecologists and Biologists confirm that excreta from five different types of animals, two types of birds and two types of insects can even revive the soil of barren lands. They are, Animals:- Cows, Elephants, Deers, Goats and Horses; Birds:- Chicken and Ducks; Insects:- Dung beetle and Termites. Among the animals it is easy to grow and protect cows as they are the most domesticated.

This fact is known to Bishnoi tribes of Thar desert region in India – where these tribes were able to convert the desert lands into an Agricultural land -

using Cow dung and excreta of Goats, Horses and Camels. They also reared peacocks instead of Chickens and ducks. These life-forms have contributed to the changing of the terrain from a barren one to a fertile one in large parts of the desert.

5.6.3 Cow-urine and Bio-enhancement

Cow urine improves efficacy of the medicine/chemical according to the scientists of the Central Institute of Medicinal and Aromatic Plants (Lucknow, India), who have demonstrated that cow urine contains chemicals that act as 'bio enhancers'.

Agricultural scientists have found that Cow's urine is rich in organic urea which acts as both nutrient and hormone. Cow's urine has about 90% water and rest minerals such as calcium sulphate, magnesium sulphate, potassium hippurate.

The potency of all botanical inputs can be enhanced through the usage of Cow urine as an addendum. Mixing plant inputs in cow urine is a common practice prescribed in *Vṛkṣāyurveda* for improving efficacy of the plant inputs and which in-turn results in better growth and efficacy in medicinal plants.

5.6.4 Green manure, mulching and Organic nitrogen

Green manure and mulching increases Organic nitrogen compounds in soil. *Vṛkṣāyurveda* texts recommend green manure before sowing /planting and also mulching around growing plants.

A study in 2006 by the scientists at the University of Lancaster and Britain's Institute of Grassland and Environmental Research, Professor Richard Bardgett and his team have found that organic nitrogen compounds can be easily absorbed by plants. In addition, these nitrogen compounds are used by various plant species differently, which include enabling nitrogen sharing among different species of plants and helping in increasing biodiversity.

This research provides important new information about what happens to organic nitrogen in real ecosystems in real time. The research results have appeared in the April 2006 edition of 'Business', a magazine of Britain's Biotechnology and Biological Sciences Research Council.

5.7 Plant protection

Various plant protection methods are described in detail in this sub-chapter.

5.7.1 Pest control in Medicinal plants cultivation

The *Vṛkṣāyurveda* text Lokopakara mentions that mixing *hingu*, *vachā, maricā, vidaṅga, aruṣkara, sarṣapa* and cow's horn in cow's urine and putting this mixture around the roots of a plant protects it from insects [119].

Aśvattha	Ficus religiosa
Nyagrodha	Ficus bengalensis
Ajaśṛngī	Gymnema sylvestre
Ayasmayī	Aloe vera Toarn
Guggulū	Commiphora mukul
Pīlā	Salvadora persica

[119] Lokopakara 6.11

Muṣka	Simplocos racemosa
Naladī	Nardostachys grandiflora
Aukṣagandhi	Fatatus paniculata
Haritakā	Terminalia chebula
Arjunā	Terminalia arjuna
Mahāvṛkṣa	Euphorbia tirucalli
Sikhaṇḍī	Jesseminum oriculatum
Aghāta / Apāmārga	Achyranthes aspera
Hiraṇyaparṇā /Hiraṇyayī, Arāṭakī	Odina wodiar
Palasa	Butea frondosa
Vidanga	Embelica ribes
Kuverakṣī	Bignonia suaveolens

Table No. 5.3 Botanical (Plant) pest control substances from *Atharva Veda*[120]

सेचयेत्कृमिभिर्जग्धां लतां च खलिकाजलैः ।
जयेद्भस्मेष्टकाचूर्णैर्द्धूलनं च कृमीन् दले[121] ॥

A creeper infected by insect pests must be sprinkled with water mixed with oil cake. Insects on the petals may be overcome by dusting with a mixture of ash and powdered brick.

Application of Ash, brick power, dried cow dung power are continued to be used in tribal agricultural practices for pest control, till date. These Agricultural ITK (Indigenous Technical Knowledge) are studied, validated and recorded by ICAR (Indian Council for Agricultural Research) during the nation-wide study in 2003-2005.

[120] Atharva-veda 4.37

[121] Surapāla-vṛkṣāyurveda 1.197

आरग्वधारिष्टकरञ्जसप्तपर्णत्वचां जन्तुरिपोश्च चूर्णैः ।
मूत्रैर्गवां पर्युषितैः प्रलेपात्कृमीन् जयेत् बाह्यगतान्स्तरूणाम् ॥
विडङ्ग-सीध्दार्थ-कटुत्रयेण गोमूत्र-भल्लातवचायुतेन ।
लेपेन शाखान्तरकान् कृमीन् वै हरेत् सवर्णान् कुरुते त्वचः द्रोः[122] ॥

To control both the insects and plant diseases, '*aragavadha*' (Cassia fistula), '*ariṣṭa*' (Sapindus emarginatus), '*karañja*' (Pongamia pinnata), '*saptaparṇa*' (Alstonia scholaris), *Vacā* (Acorus calamus), '*siddhārtha*' (Sinapis alba) with '*trikaṭu*' and '*vidaṅga*' (Embelia ribes) should be soaked overnight in Cow urine and applied /sprayed on affected parts.

5.7.2 Plant specific pest control substances

Every one of the *Vṛkṣāyurveda* text describes several Plant protection methods which include both pest control and disease control using botanicals along with bovine products. Over 300 botanical (plants) substances can be compiled from various *Vṛkṣāyurveda* treatises. These 300 plus plants have their secondary metabolites which act as pest repellents and also provide pathogen resistance.

Secondary metabolites are plant chemical compounds which are different from that of primary metabolites such as carbohydrates, protein and other hydrocarbon compounds. These compounds are used by plants to protect themselves from Biotic and Abiotic stress. Secondary metabolites of medicinal plants are used as medicinal compounds by human beings.

[122] Viśvavallabha 8.39 – 40

Secondary metabolites are intermediates and products of plants' metabolism. These are natural plant products, and are response to the ecology of plants. These secondary metabolites have pharmaceutical properties of defense against predators such as insects and pathogens. In comparison with primary metabolites these are not essential for plant growth and are not always present in plants. These are expressed only when there are Biotic and Abiotic stress conditions.

Therefore, medicinal plants need to be cultivated in Agroforestry model along with other plants to have appropriate environment and get exposed to Biotic and Abiotic stress.

Based on modern pharmacological studies, Alkaloids – one of the important secondary metabolite (natural plant chemical) substances such as Azadirachtine, Rotenone, Nicotine, Pyrethrins, Lemonene, etc. control pests and also disease causing microbes. Similarly, Tanins, control Fungal growth and bacterial infections.

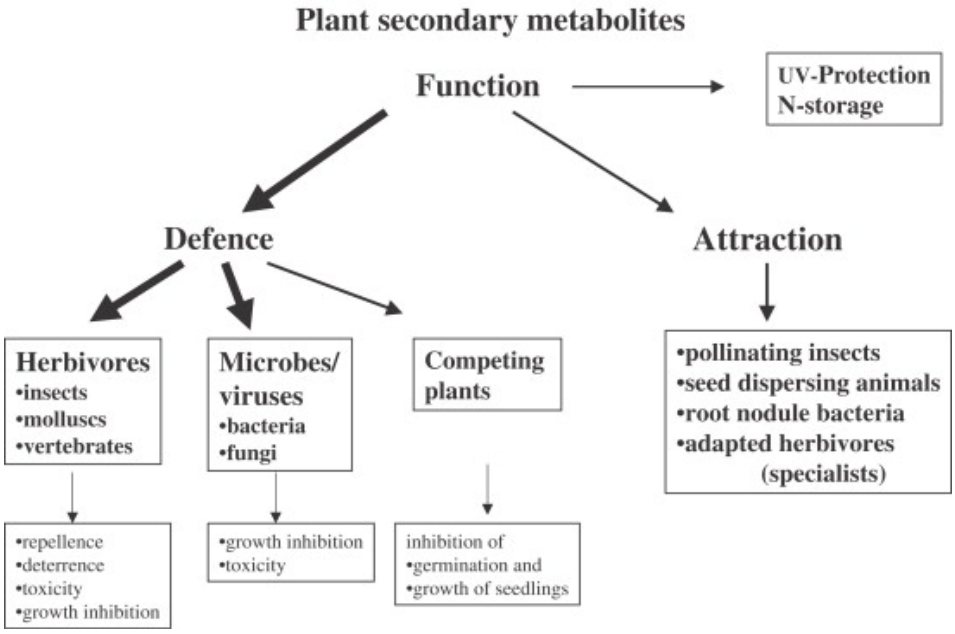

Figure: 5.3 Functions of Plant secondary metabolites[123]

[123] *Source: Michael Wink, Importance of plant secondary metabolites for protection against insects and microbial infections, Chapter 11, "Naturally Occurring Bioactive Compounds" - edited by Mahendra Rai, María Cecilia Carpinella, Volume 3, (2006)*

Botanical substance	द्रव्यगुणाः Pharmacology	आयुर्वेदीय-कर्म Ayurvedic action	Phytochemical compounds	Purpose of application
निम्बद्रव्यम् ('nimba') Azadirachta indica	Rasa = tikta Guṇa = snigda /laghu Vīrya = śīta-vīrya Vipāka = kaṭu	'*Kṛmibedana*' (Destrution of microbes)	Terpenoids, Monoterpenes	Antifeedants Antimicrobial Contact toxicant Insecticidal
हरिद्रा ('*haridrā*') Curcuma longa	Rasa = kaṭu, tikta Guṇa = rūkṣa /laghu Vīrya = uṣṇa-vīrya Vipāka = kaṭu	'*Kṛmighna*' (Antimicrobial)	Alkaloids, Phenolics	Anti-inflamation Fumigant Antimicrobial
विडङ्गम् ('*vidaṅga*') Embelia ribes	Rasa = kaṭu, tikta Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	'*Kṛmighna*' (Antimicrobial)	Polyphenolic compounds, Terpenoids	Antibacterial Anthelmintic Insecticidal
निर्गुण्डी ('*nirguṇdī*') Vitex negundo	Rasa = kaṭu, tikta Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	'*Kṛmighna*' (Antimicrobial)	Alkaloids, Limonoids	Antifungal Antibacterial Insecticidal
सिद्धार्थः ('*siddhārtha*') Sinapis alba	Rasa = kaṭu Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	*'Kṛmibedana'* (Destruction of microbes)	Polyphenolic compounds, Phytoalexins	Pest Repellent and Helps plants to develop antixenosis
वचा ('vacā') Acorus calamus	Rasa = kaṭu, madhura Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	'*Kṛmighna*' (Antimicrobial)	Monocyclic sesquiterpene ketone	Antibacterial Insecticidal

स्नुही (‘snuhī’) Euphorbia Antiquorum	Rasa = tikta Guṇa = snigda /laghu Vīrya = śīta-vīrya Vipāka = madhura	‘*Kṛmighna*’ (Antimicrobial)	Triterpenes, Polyphenolic compounds, Phytoalexins	Antimicrobial Insecticidal Helps plants to develop antixenosis
अतिविषम् (‘ativiṣa’) Aconitum heterophyllum	Rasa = kaṭu, tikta Guṇa = rūkṣa /laghu /tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	‘*Kīṭanāśaka*’ (Insecticidal)	Polyphenolic	Insecticidal Rodenticidal Antibacterial
पञ्चतृणमूलम् (‘pañca-tṛṇamūla’) Mixture of 5 grasses	Rasa = kaṭu, tikta Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	‘*Kṛmighna*’ (Antimicrobial)	Triterpenoid saponins	Molluscicidal Antifungal Antiviral Insecticidal
यष्टिमधु (‘yaṣṭimadhu’) Glycyrrhiza glabra	Rasa =madhura /kaṭu Guṇa = rūkṣa /laghu Vīrya = śīta-vīrya Vipāka = madhura	*‘Vātapittahara’* (Balance of Bile and Wind)	Alkaloids, glycosides, phenolic compounds	Anti-microbial Insecticidal
पञ्चपल्लवम् (‘pañca-pallava’) Mixture of 5 grass	Rasa = kaśāya, tikta Guṇa = rūkṣa /laghu Vīrya = śīta-vīrya Vipāka = kaṭu	‘*Kṛmighna*’ (Antimicrobial)	Triterpenoid Polyphenolic compounds,	Antifungal Antimicrobial Insecticidal
पञ्चतुलसी /चतुष्तुलसी (‘*pañca-tulasi’)* mix of 5 types of Ocimum leaves	Rasa = kaṭu Guṇa = rūkṣa /laghu / tīkṣṇa Vīrya = uṣṇa-vīrya Vipāka = kaṭu	*‘Kṛmibedana’* (Destrution of microbes)	Polyphenolic compounds, Phytoalexins	Pest Repellent and Helps plants to develop antixenosis Antimicrobial

Table No. 5.4 - Botanical pest controls substances of *Vṛkṣāyurveda* and their Ayurvedic ‘dravya-guṇa’ properties.

According to of Haryana Agricultural University, plants having insecticidal activity possess the qualities of '*sara*' (mobile), '*snigdha*' (soothing), '*sūkṣma*' (minuteness) '*uṣaṇa*' (hot), '*rūkṣa*' (dry), and '*tīkṣṇa*' (penetrating). perceived earlier. Plants with antimicrobial characteristics possess '*tīkṣṇa'* as one of the important '*guṇa*'. Plants with insecticidal characteristics possess '*rūkṣa*' as one of the important '*guṇa*'.

पञ्चतृणमूलम् (Five roots) - is a plant tonic and anti-fungal /anti-microbial agent for various medicinal plants cultivation such as 'kuṃkuma' (Crocus sativus), 'jatāmaṃsi' (Nordostachys jatamansi), 'śveta-muśalī' (Chlorophytum borivilianum) plants. The substance *'pañca-tṛṇa-mūla'* or 'tṛṇa-pañca-mūla' consists of dry blades and leaves of '*darbha /kusha'* grass (Desmostachya bipinnata), '*cogon'* grass (Imperata cylindrica), '*kamsa'* grass (Saccharum spontaneum), '*shara'* grass (Saccharum munja) and *'ikṣu'* leaves (Saccharum officinarum). This formulation is used in Ayurveda for treatment of a number of human diseases and for human microbial infections

पञ्चपल्लवम् (Five plants) - आम्रम् ('āmra' - Mangifera indica), जम्बू ('jambū' - Syzygium jambolanum), कपित्थम् ('kapittha' - Feronia limonia), बीजपूरम् ('bījapura' - Citrus medica), बिल्वम् ('bilva' - Aegle marmelos). Dry leaf powders and also diluted fresh leaf extract decoction of these five plants are excellent pest control and disease control substance for all medicinal plants which are of *'madhura-rasa'* and *'śīta-vīrya'*.

पञ्चवल्कलम् (Five barks) - 'Nyagrodha' (Ficus bengalensis) , 'Udumbara' (Ficus glomerata), 'Ashvattha' (Ficus religiosa), 'Plaksha' (Ficus lecor), 'Vetasa' (Salix caprea). The tree bark decoction mixture /decoction of these

five plants are good pest control and disease control agents, which can be used for Ayurvedic medicinal plants of *'madhura-rasa, 'tikta-rasa'* and *'śīta-vīrya'*.

पञ्चतिक्तम् (Five bitters) - *'Patola' (Trichosanthes dioica), 'Nimba' (Azadirachta indica), 'Bhunimba' (Andrographis paniculata) , 'Rasnā' (Vanda roxburghii), 'Saptaparṇa' (Alstonia scholaris) – This mixture is a pest control for all Ayurvedic medicinal plants which are of 'tikta-rasa', 'kaśāya rasa' and 'śīta vīrya'*

पञ्चतुलसी /चतुष्तुलसी *stnalp isalut 4 / 5 fo tcartxe eht fo serutxiM ='kṛṣṇa-tulasī' (Ocimum sanctum), 'rāma-tulasī' (Ocimum gratissimum), 'śukla-tulasī' (Ocimum canum), 'vana-tulasī' (Ocimum basillicum) 'jambīra-tulasī' (Ocimum citriodorum) for Pest control of medicinal plants which are of 'kaṭu rasa' and 'uṣṇa vīrya'*

पञ्चसुगन्धिकम् (Five incense) = 'marīcā' (pepper), 'pūkiphala' (areca nut), 'lavangakusuma' (clove), 'jātīphala' (nutmeg), 'karpūra' (camphor) – for fumigation around plants during rainy season and also in medicinal plant storage chambers.

दशपर्णी अर्कम् सर्वकृमिकीटापतङ्गनिर्यापणम् –This substance which consists of 10 types of plant leaf-extracts is an overall pest control and disease control substance for medicinal plant cultivation. This substance is revived in parts of Maharashtra and being used successfully as a broad-spectrum pest repellent substance.

5.7.3 *Vṛkṣāyurveda* pest control and Chemical pesticides

The table No. 5.6 below highlights the major differences between *Vṛkṣāyurveda* based pest control substances and Chemical pesticides.

Factors	*Vṛkṣāyurveda* pest control	Synthetic chemical pesticides
Philosophy	Insect repelling. Allowing nature to take its course with respect to pest control by increase in natural pest predators. Since insects are not killed totally, the friendly (insectivorous) insects eat the pesty insects. The friendly ones also help in pollination.	Insect killing. Pest control is in the hands of human beings through the usage of synthetic chemical products. Insects can also become immune to the chemicals overtime. Since all insects are killed and the friendly insects are no longer there to control pesty insects and also help in pollination of plants.
Insect control ingredients	Mixture of two or more extracts of obnoxious botanical substances which repel the insects. These substances are not poisoness to human beings. They contain several secondary metabolites (plant-chemicals). Enhancement of the potency of these botanicals is done with the help of Cow urine.	Usually a cocktail of many neurotoxins that act on the insect organisms and kill them. These chemicals are highly toxic to both insects and all other life-forms including humans and animals. Usually a small amount of chemical pesticides is only advised to be sprayed on the plant. However farmers spray much more than what is prescribed
-Production	Produced in the agricultural fields. By the process of simple grinding the leaves, barks, seeds and mixing with water. Spraying can be done after boiling, cooling, fermenting, filtering and dilution	Produced in the factories with multiple chemical inputs and process manufacturing methods. These come in ready-to-use bottles.
Scalability	Not applicable as these botanical substances are made for seasonal usage and are made in quantities as required.	Scalable for mass production. Regulated and controlled by several standards with respect to efficacy and toxicity.
Shelf life	*Vṛkṣāyurveda* pest control substances have limited shelf-life as they are usually used within a fortnight /month. Since these substances are made on-demand in the field by the	Long shelf life due to the presence of strong and toxic chemicals

Factors	*Vṛkṣāyurveda* pest control	Synthetic chemical pesticides
	farmers, shelf-life is not a concern.	
Production cost	Very low. The raw-material are locally sourced weed /plant substances and thus the costs are very low.	High. The cost includes research, formulation, raw material, testing and certification, patenting, manufacturing, packaging, distribution and advertising, etc.
Plant specific pest control	Plant specific, insect specific, disease specific pest control substances can be made by farmers in the field using weeds	Generic neurotoxic substances, which act and kill all life forms including friendly insects. Plant specific substances are generally not available
Toxicity	Safe and harmless to other life-forms	Toxic and harmful to all life-forms
Regulatory requirements	None. As these are generally harmless mixtures of plant substances	Require, licensing, product testing and approvals including toxicity tests.

Table No. 5.5 *Vṛkṣāyurveda* pest control and Chemical pesticides

5.7.4 Fumigation

Ayurveda recommends inhaling herbal smoke especially for treating respiratory (*vāta* and *kapha*) disorders in humans, similarly many *Vṛkṣāyurveda* texts recommend fumigation for treatment of certain disorders in plants. Fumigation is also important process for pest control and also microbe control in *Vṛkṣāyurveda* both during plant growth phase and also in storage.

In recent years, biologically active compounds have been isolated from smoke with potential uses in agriculture and horticulture. In Arunachal Pradesh of India, the ethnic Nocte tribe has maintained an age-old traditional slash-and-burn farming system on hill slopes (Kulkarni *et al.*, 2011). Flematti et al. (2004) reported for the first time a germination-promoting compound in

plant- and cellulose-derived smoke. The following are the list of substances found in various *Vṛkṣāyurveda* texts[124]

White mustard seed powder, dried flowers of arjuna tree, dried vidanga (Embelia ribes) seeds, turmeric powder, triphala powder, amalaki (Emblica officinalis), haritaki (Terminalia chebula), bibhitaki (Terminalia bellirica), sesame powder, barley powder, ramatha (Ferula asafetida) powder, vacha (Acorus calamus) powder, usana or krishna maricha (Piper nigrum), plantain leaf, Indian bdellium (guggulu; Commiphora wightii), long pepper (Piper longum), aconite (Aconitum napellus), bhallataka (Semecarpus anacardium), costus root (Saussurea lappa), koshataki leaves (Luffa acutangula), shipha Turmeric (Curcuma domestica), indrabeeja (Citrullus colocynthis), leaves of kadali (Musa paradisiaca), unmatta (Datura metel), vatarika (garlic), mallika (Jasminum sambac) flowers, sinduvara (Vitex negundo), masha (black gram) powder, yava (barley), husk of a cereal, nirgundi (Vitex negundo) powder, sarpi (Sansevieria roxburghiana), kubera (Ficus microcarpa), netra (Opuntia elatior), seed of asana (Pterocarpus marsupium), sita (Pueraria tuberosa), nimbu (Citrus aurantifolia), musta (Cyperus rotundus)

5.7.5 Foliar absorption of chemicals by plants

Plants absorb nutrition, water and other substances directly through foliage (leaves). The rate of absorption through foliage is although slower in comparison to the rate of absorption through roots, it is still high with respect to leafy plants and herbs. This absorption applies to both harmful chemicals as well as beneficial botanical substances. This is the main reason for the

[124] "Fumigation of plants in Vrikshayurveda", Nene Y.L., Full length paper, Asian Agri-History, Vol. 18, No.1, 2014

restriction of chemical Pesticide /Fertilizer application and thereby contamination in medicinal plant products.

World Health Organization GAP (Good agricultural practices) guidelines and country specific guidelines of US, EU, Canada, etc. prohibit the usage of chemical substances such as fertilizers, pesticides and herbicides for the cultivation Medicinal Plants as the harmful chemical substances can be absorbed by the Medicinal plant through foliage.

Chemical substance	Absorption rate (Time)
Nitrogen (as Urea)	30 minutes to 120 minutes
Phosphorous	5 – 6 days
Potassium	10 – 24 hours
Calcium	10 – 24 hours
Magnesium	10 – 24 hours
Chlorine	1 – 4 days

Table No. 5.6 : Foliar absorption rates of agricultural chemicals[125]

***Sātmya-vīrya-dravya-prayoga* (usage of substance with compatible efficacy)**

According to the principles of Ayurvedic '*dravya-guṇa-vijñāna*' (pharmacology) application of incompatible substance in the foliage for a particular host plant's growth or pest control, results in negative effects in the host plant's characteristics with respect to '*rasa*' (taste), '*vīrya*' (potency /efficacy), and '*guṇa*' (property) and creates potential changes in the medicinal efficacy aspects of the host plant. This could also result in the host plant inheriting incompatible '*vīrya*' (potency /efficacy) of the incompatible substance applied to the foliage from an Ayurvedic pharmacological aspect.

[125] Kugler booklet

E.g.: The medicinal plant '*āmalakī*' (Phyllanthus emblica) which by nature according to Ayurveda pharmacology has '*madhura-rasa*' (sweet taste) and '*śīta-vīrya*' (cold-potency). When '*āmalakī*' is grown with the help of spraying with the extracts of '*lasūna*' (Garlic – Allium sativum) a WHO approved botanical pest repellent, and finally the harvested '*āmalakī*' may have inherited subtle characteristics of garlic with respect to '*vīrya*' (potency /efficacy) through foliar absorption. Thus the '*vīrya*' (potency /efficacy) of '*āmalakī*' could have changed to '*uṣṇa-vīrya*' (hot-potency) from its natural '*śīta-vīrya*' (cold-potency). As a result, when in a particular medicinal formulation which uses the '*āmalakī*' (Phyllanthus emblica) herb for its '*śīta-vīrya*' (cold-potency) may have '*uṣṇa-vīrya*' (hot-potency).

कीटादिनिर्यापणार्थम् औषधीनां तूलभागेषु अथवा मूलभागे च विरुद्ध -वीर्य-द्रव्य-सिञ्चनं औष्धीभ्यः विरुद्धाहारवत् पोषाय कल्पते । अनेन विरुद्ध -वीर्य-द्रव्य-सिञ्चनेन औषधीषु संयोगविरुद्धः कर्मविरुद्धः रसविरुद्धः च सञ्जायन्ते । अपि च विरुद्धवीर्यलक्षणम् औषधीनां धर्मेऽपि आविर्भवति । इत्यतः विरुद्धवीर्यद्रव्यप्रयोगः निवार्यः । इत्ययं सिद्धान्तः अनेन अनुसन्तानप्रबन्धद्वारा निरूप्यते [126]॥

Usage of pest control substances incompatible from that of the host medicinal plant, based on the Ayurvedic potency /efficacy should be avoided. These pest control substances can cause '*saṃyoga-viruddha*' (formulatory issues) '*karma-viruddha*' (resultant action issues), '*rasa-viruddha*' (taste attribute issues) in the host medicinal plant and the medicinal plant's characteristics could also be impacted. Therefore, the usage of incompatible substances for medicinal plants cultivation should be avoided. This theory is proposed through this research thesis.

[126] Essence from various Vṛkṣāyurveda texts

वीर्यप्रधानमौषधद्रव्यं, तथा रसप्रधानमाहारद्रव्यम्[127] ।

'Vīrya' (potency /efficacy) is the most important attribute of Medicinal substance and *'Rasa'* (taste) is the most important attribute of the Food substance.

योगादपि विषं तीक्ष्णमुत्तमं भेषजं भवेत् ।
भेषजं चापि दुर्युक्तं तीक्ष्णं सम्पद्यते विषं ॥
तस्मान्न भिषजा युक्तं युक्तिबाह्येन भेषजम् ।
धीमता किञ्चिदादेयं जीवितारोग्यकङ्क्षिणा [128]॥

Due to proper formulation even a highly poisonous substance can become medicine and the same way even a medicinal substance can become toxic due to improper formulation. Therefore, a good doctor should logically arrive at a medicinal formulation based on logical and acceptable parameters.

'Four basic attributes are given to an ideal 'auṣadham' (medicine) pertaining to both an ingredient of a whole preparation, as well as a poly constituent formulation.

These are 1. 'Bahu-kalpam', which can be used in varieties of dosage forms like decoction and oils. 2. 'Bahu-gunam' means having more than one attribute like Tinospora cordifolia, which has many uses. 3. 'Sampannam', which refers to natural attributes and is critical for quality control. To ensure that the 'sampannatā' is present in herbal ingredients, many attributes must be assessed. 4. 'Yogyatā' means suitability of a medicine in a given context.

[127] Caraka-saṃhtā, sūtrasthāna, 2.17

[128] Caraka-saṃhtā, sūtrasthāna, 1.126 & 1.127

Present day scientific instrument-based standardization cannot measure 'sampannatā.' This opens up the need for developing Ayurveda-based methodologies of quality control[129]*'.*

5.7.6 Pest categories and control

For effective pest control it is essential to understand the pest categories, *Vṛkṣāyurveda* texts detail 3 major categories of pests and also offer several methods to control them. The following Figure No. 5.4 provides categories of pests and the pest control methods and substances

[129] *Dr. G.G. Gangadharan, Quality of ingredients used in Ayurvedic herbal preparations, Journal of Ayurveda Integrative Medicine, 2010 Jan-Mar; 1(1): 16–17., doi: 10.4103/0975-9476.59821, PMCID: PMC3149385*

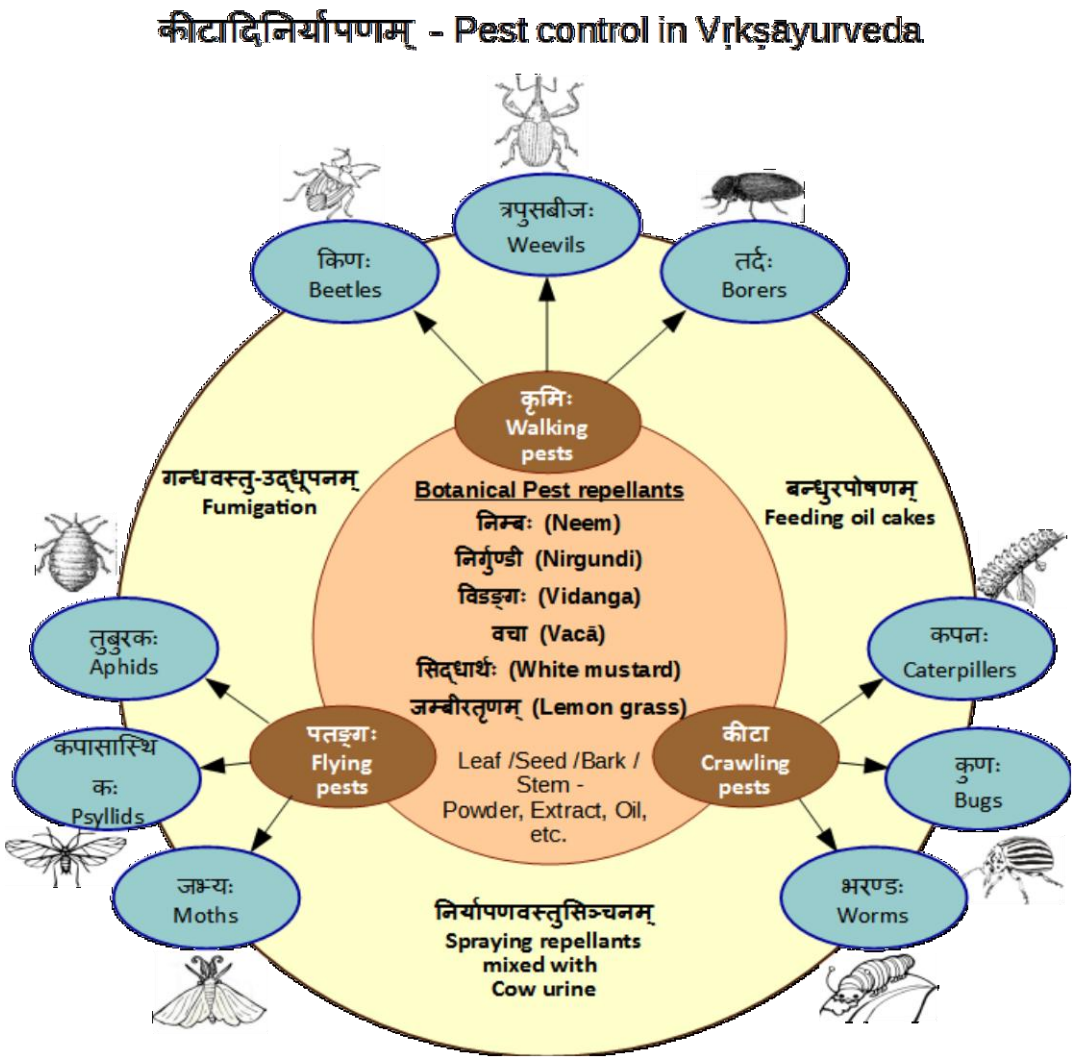

Figure 5.4: Pest categories and pest control substances

5.7.7 Plant disease control & protection

Ayurveda principles establish that the root cause of human diseases the imbalance of '*tridoṣa*' namely '*vāta*', '*pitta*' and '*kapha*'. Similarly, plants are also susceptible to diseases due to the imbalance of '*tridoṣa*' (internal) and also other external factors.

शरीर-आगन्तु भेदेन द्विप्रकाराः समासतः ।
सर्वभूरुहजातीनाम् अन्तकः परिकीर्तितः ॥

तत्र वातात्कफात्पित्तात् शरीराणां समुद्भुवाः ।
आगन्तूनां समुत्पत्तिः कीट-शीतादिभिः भवेत्[130] ॥

Imbalance of '*tridoṣa*' caused ailments are internal diseases. The external diseases are those which are caused due to climate change primarily cold weathers and pest /microbial attack.

सूक्ष्मयोनीनि भूतानि तर्कगम्यानि कानिचित् ।
पक्ष्मणोपि निपातेन येषां स्यात् स्कन्धपर्ययः[131] ॥

'There are micro-organisms, which you may not be able to see, but can infer, whose shoulders break just with the (force of) eyelids twitching'

The table 5.8 highlights various diseases of plants caused by both internal factors due to imbalance of '*tridoṣa*' of and external factors of seasonal changes and pest attacks and also the indications and treatments. These are compiled from '*Surapāla-Vṛkṣāyurveda',* where these details are elaborated in over 55 verses in a detailed manner based on various plant types, disease types and remedial actions.

Plant diseases and treatments in *Surapāla-Vṛkṣāyurveda*[132]

Disease	Cause	Indications	*Vṛkṣāyurveda* treatments
'*vāta*' disorders	Excessive dryness in land and in plant	Thinning of trunks and branches, crookedness of branches, knots in the leaves, sweetlessness in fruits and also not growing	'*Kuṇapa jala*', green manure and mulching. Fumigation with herbs and Cow horn

[130] Surapāla-vṛkṣāyurveda 1.165, 166

[131] Mahābhāratam, śāntiparva – 12.14.26

[132] Surapāla-vṛkṣāyurveda - Verses from1.165 to 1.222

		properly and being hard. Excessive Leaf fall, etc.	
'*kapha*' disorders	Winter, coldness and water logging	Paleness and dwarfing of leaves, prematurity of fruits. Oozing of sap, root-rot, etc.	Bitter, astringent decoctions based plant tonics, white mustard paste, powder at the root of plants. Drainage and removal of excessive mulch, etc.
'*pitta*' disorders	Excessive heat, and excessive watering with salty water	Yellowness and paleness in leaves, excessive leaf falling, fruit and flower falling before maturity	Watering with sweet and cold water, watering with decoctions of fruits and '*triphala*', etc.
Combination all '*doṣa*'	Faulty seed, lack of seed treatment	Plant loosing leaves, flowers and fruits and excessive leaf fall, crookedness of branches, etc.	Seed treatment with '*Kuṇapa jala*'
Other diseases	Pest and worm infestation in plants and roots	Visible plant problems due to pests	Cow urine with mixture of plant extracts of *'siddhārtha', 'vāca', 'vidaṅga', 'uśaṇa', 'triphala', 'snuhi'*, etc. Fumigation with Neem and vidanga powders to ward off flying pests.

Table No. 5.7 Plant diseases, causes and *Vṛkṣāyurveda* treatment methods

चिकित्सितमथैतेषां शस्त्रेणादौ विशोधनम् ।
विडङ्गघृतपङ्काक्तान् शेचयेत् क्षीरवारिणा[133] ॥

In order to treat diseases in plants, one first has to cut off the affected parts with a suitable instrument. Then, the tree (or the affected parts) must be smeared with a mixture of *vidanga,* ghee and clay mixture. A liquid mixture of milk and cold water must be sprinkled at the base of the tree.

[133] Bṛhatsaṃhitā – 55.15

अविकाजशकृच्चूर्णस्याढके द्वे तिलाढकम् ।
सक्तुप्रस्थो जलद्रोणे गोमांसतुलया सह ॥
सप्तरात्रोषितैरेतैः सेकः कार्यो वनस्पतेः ।
वल्मीगुल्मलतानां च फलपुष्पाय सर्वदा [134]॥

Mixture of two '*āḍhaka*' of goat dung powder with one '*āḍhaka*' of sesame powder, one '*prastha*' of '*sakthu'*, one '*droṇa*' of water and one '*tulā'* of beef, the mixture o these to be kept for seven nights, and then sprinkled to all medicinal plants – shrubs, creepers and trees, etc. This would ensure that all the plants bear flowers and fruits for all time and also have good growth.

The Ayurvedic '*triptighna-mahākaṣāya*' (anti-satiate) substances which are human medicinal substances, can be used for treatment of various plant diseases. The 'triptighna-mahākaṣāya' plants are, '*Nāgara'* (Zingiber officinalis), *Cavya* (Piper chaba), *Citraka* (Plumbago zeylanica), *Viḍaṅga* (Embelia ribes), *Mūrvā* (Clematis triloba), *Guḍūcī* (Tisnpora cordifolia), *Vacā* (Acorus calamus), *Musta* (Cyperus rotundus), *Pippalī* (Piper longum), *Paṭola* (Trichosanthes cucumerina).

5.7.8 Protection from Sun, heat and snow /mist

Key *Vṛkṣāyurveda* texts such as *'upavana vinoda'* and *'surapāla Vṛkṣāyurveda'* recommends Sun /heat control and the text 'viśvavallabha' recommends covering the plants from mist /snow. This are very similar to the greenhouses (polyhouse) and shade-nets in contemporary agriculture.

नवरोपितवृक्षाणां कार्यम् आतपवारणम् ।
यावत् प्रवालसंकाशा जायन्ते पादपा नवाः[135] ॥

[134] Bṛhatsaṃhitā – 55.17-18

[135] Surapāla vṛkṣāyurveda 1.108

Newly planted plants must be protected from direct sunlight. Then, these new plants will grow very well.

घनप्रवालस्थगितातपानि विकीर्णपुष्पाणि समीरणेन ।
उपवनानि कुर्यादतिमुक्तकानां लताभिरालोलमधुव्रताभिः [136]॥

In agroforests, small plants must be covered with the big plants, which protect them from rain, wind and sun, the flowers of which are spread out due to breeze, and which is shaken slightly by the movement of bees.

अल्पाङ्घ्रिपाणमपि मण्डपेन तृणादिभिः वेष्टनकेन शश्वत् ।
पादादीन् आच्छादनकेन कुर्यात् स्वल्पे तुषारस्य च रक्षणं वै [137]॥

Protect the small plants from frost /snow by implementing temporary sheds of grass thatch covering the small plants' '*aṅghripāṇa*' root and shoot. Also the root area needs to be covered with leaves (mulching).

कुट्या अथवा कण्टकिरोपणेन रक्षा द्रुमाणां परिखाविधानम् ।
कार्यान्यथा वा चतुरैश्च पुंभिः युक्त्या यथाकालम् अथोखिला [138]॥

Farmers should protect the plants by constructing temporary shade or by growing thorny plants or by digging trenches around as per the season.

5.8 Environmental factors and Efficacy of MAP plants

One of the key criteria for the cultivation of Medicinal plants *Vṛkṣāyurveda* method is the protection of 'medicinal efficacy'. In Sanskrit this is referred as '*bhaiṣajya śakti*' of medicinal herbs. This is also known as

[136] Upavana vinoda 1.83

[137] Viśvavallabha 6.6

[138] Viśvavallabha 6.8

'*vīrya*', as per Ayurvedic '*dravya-guṇa-vijñāna*', however this term is primarily used for denoting potency of a medicinal substance.

The reason for better medicinal efficacy of Wild collected medicinal plants is due to multiple factors including Biotic stress (alleopathic interactions with other plants) and Abiotic stress meaning water availability, weather and environmental factors, Seasonal variations, soil conditions, etc. Figure 6.6 next page gives the detailed account of Weather and environmental factors influencing the medicinal efficacy of medicinal plants

The model of Agroforestry for the cultivation of Medicinal and Aromatic plants is primarily for the purpose of mimicking the wild environment and providing the necessary conditions where by the MAP encounters moderate Biotic and Abiotic stress.

सूर्योदये विषुवतो जगतां विपत्तिर्मध्यं गते दिनकरे बहुशस्यहानिः ।
अस्तं गते दिनकरे तु तदर्धशस्यं ऐश्वर्यभोगमतुलं खलु चार्द्धरात्रे[139] ॥

The *viṣuva* (vernal equinox), if it takes place at sunrise, there will be calamity on the earth; if it is at noon, there will be great crop loss; if it occurs at sunset, only half the expected yield is obtained; if it happens at midnight, there will be unmatched prosperity.

Environmental factors and agricultural processes play a major role in the cultivation of medicinal plants and also its characteristics, in particular the medicinal efficacy. The Ayurvedic canon '*Carakasaṃhitā'* details this in many places in the text.

[139] Kṛṣiparāśara 1.53

यत्तु द्रव्यभूतं तद्वमनादिषु योगमुपैति । तस्यापीयं परीक्षा , इदमेवं प्रकृत्या एवंगुणम् एवंप्रभावम् अस्मिन् देशे जातम् अस्मिन् ऋतौ एवं गृहीतम् एवं निहितम् एवम् उपस्कृतम् अनया मात्रया युक्तम् अस्मिन् ऋतौ एवंविधस्य पुरुषस्य एतावन्तं दोषम् अपकर्षयति उपशमयति वा अन्यदपि च एवं विधं भेषजम् भवेत् च अनेन विशेषेण युक्तम् इति[140] ॥

That medicinal substance (plant) which is used for various treatments starting with emetic function, need to be examined depending on various agricultural and environmental parameters as given in the table 5.8.

Medicinal Plant (substance)	Characteristics
'prakṛti'	Natural quality
'guṇa'	Guṇa (one of the '*rasapañcaka*' attribute)
'prabhāva'	Special quality
'jāta'	Cultivation - type of land, soil, etc.
'Ṛtu'	Season
'gṛhīta'	Harvest - season and type
'nihita'	Storage - Manner, type, containers, etc.
'upaskṛta'	Processing types: drying, powdering, decoction, trituration, pulverization, etc.
'mātrā'	Posology, etc.

Table No. 5.8 – Medicinal plants and their base characteristics for storage

[140] *Carakasaṃhitā, Vimānasthāna 8.87*

It is therefore important that the medicinal efficacy and effectiveness of Ayurvedic formulation and/or drug are determined based on the method of cultivation of medicinal plants. This is in addition to other parameters such as posology, etc.

बहुता तत्रयोग्यत्वमनेकविधकल्पना ।
सम्पच्चेति चतुष्कोऽयं द्रव्याणां गुण उच्यते[141] ॥

Medicinal formations are available in plenty. The four qualities of '*dravya'* (medicinal substances) are determined based on '*bahutā*' (easy availability), '*yogyatva*' (appropriateness), *'anekavidha-kalpanā'* (preparations or formulations in various forms) , '*saṃpat*' (inherent properties).

From the above verse it is understood that the prerequisites for making effective Ayurvedic medicines lie in availability, properties and appropriateness of the medicinal substances which effectively means the availability of Medicinal and Aromatic Plants with good efficacy in plenty.

> *'There are further considerations of great importance in determining quality of plant ingredients in herbal formulations, including place of origin, method of cultivation (mono-culture or multi-culture crop etc.), time, season, methods of collection and storage. All these parameters play important roles in final plant quality and should therefore be listed among a given plant's attributes and applied to all herbal ingredients'.*
>
> *Each of these should be studied for individual plants and objective standards evolved. For example, for many plants, particularly when roots and stems are used, secondary metabolites determine therapeutic activity, so availability of*

[141] Carakasaṃhitā, Sūtrasthāna 9.7

these is important. This is an area requiring careful explanation. Many plants, though grown with great care and nourishment, are not found to be effective, because they lack the necessary Veerya. Veerya may even be derived from secondary metabolites formed in a plant out of stress and starvation. For example, relatively smaller specimens of Haridra (Haldi, Turmeric), grown under demanding, dry conditions in Tamil Nadu are far more potent, with greater concentration of curcumin, than the same variety grown in damp conditions.

Ayurveda recommends not collecting plants during the rainy season or immediately after it. This is to prevent the Veerya being diluted. Certain plants, especially root tubers, have to remain underground for a specified period before they are collected. This ensures better therapeutic activity. Certain plant material loses its activity merely from exposure to sunlight e.g. Haridra. Some plants need to be processed in particular materials to obtain their full efficacy e.g. Piper longum in milk. Some are synergistic and become more effective when used together e.g. Sali parni and Prushni parni.'

The above text in '*italic typeface*' is quoted as it is from the journal article[142]

Various agronomic and environmental factors affecting the medicinal efficacy of medicinal plants and their specific effect such as Abiotic, Edapic, etc. are depicted in a detailed manner in Figure 5.5. These are taken from various *Vṛkṣāyurveda* texts including *Bṛhatsaṃhitā* and *Kṛṣi parāśara*.

[142] *Dr. G.G. Gangadharan, Quality of ingredients used in Ayurvedic herbal preparations, Journal of Ayurveda Integrative Medicine, 2010 Jan-Mar; 1(1): 16–17., doi: 10.4103/0975-9476.59821, PMCID: PMC3149385*

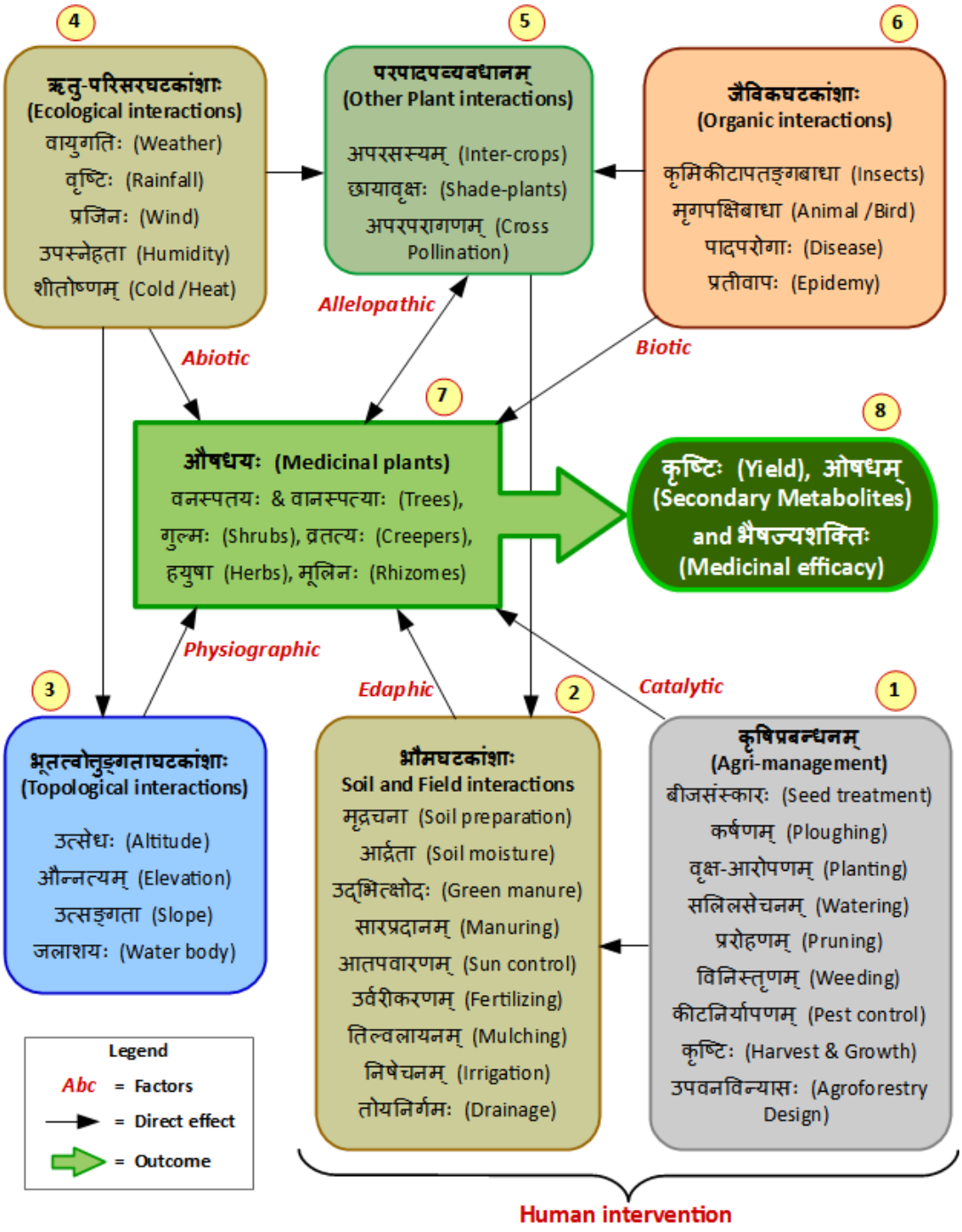

Figure No. 5.5: Weather and other factors influencing medicinal efficacy

5.8.1 Influence of Agronomic conditions in medicinal efficacy

Plants need water, soil fertility, humus, and protection for proper growth, this is applicable to medicinal plants too.

फलपुष्पवृद्धिहेतुः रोपणं शोधनं तथा ।
पादपानां यथाकालं कर्तुं भूमि-जलादिना ॥
तद् भेषजं च संवेत्तिः हि आराम-अधिपतिश्च सः[143] ॥

For the proper growth of fruits and flowers, planting and maintaining of plants are essential according to the season through soil and water management. In addition to that the one who knows the medicine for plants (plant diseases) is indeed the lord of Agroforest.

नानावीर्याः ओषधीः याः बिभर्ति ।
पृथिवी नः प्रथतां राध्यतां नः [144]॥

Mother Earth which manifolds and protects many medicinal herbs shall protect us and propitiate us.

Various agronomic conditions influencing medicinal properties in plant products and herbal raw materials. The following table highlights these.

Agronomy	Parameters
Land type	Altitude, slope and topography, Wet-land, Ordinary land and Arid /Semi arid land, etc.
Soil types and conditions and soil management	Color, permeability, humus, texture, fertility and water availability.

[143] Śukranītisāra 2.158

[144] Suśruta-saṃhita, Sūtrasthāna 45.263

Seed collection	First seed collection, QPM (Quality planting material) Qualitative & quantitative parameters
Seed treatment prior to planting	Seed soaking, besmearing, drying in Sun and exposing to mist in the night, etc.
Planting method	Broadcasting, direct seeding, transplanting, planting stem cuttings, planting pit preparations, seed-bed maintenance, etc.
Manuring	Types (solid, liquid), 'kuṇapa-jala' /'sasya-gavya' preparation and application, bio-availability, growth stimulants, green manure, composts, etc.
Water quality and irrigation	Salinity, hardness, water retention and drainage Water treatment before irrigation, mix of herbs in water
Plant protection	From heat and sun light From mist From pests From diseases From herbivores From fires and smoke
Harvest	Seasons Part collection – leaves, seeds, stems, roots, etc. Collection methods Timings
Pre-processing & Storage	Cleaning of the harvested medicinal substances Washing and draining Drying methods – Sun, Shade Fumigation Storage boxes & Storage chambers

Table No. 5.9 Agronomic conditions influencing medicinal properties

The cultivation differences between Food crops and medicinal plants are given in the next page pictorially in Figure No. 5.6

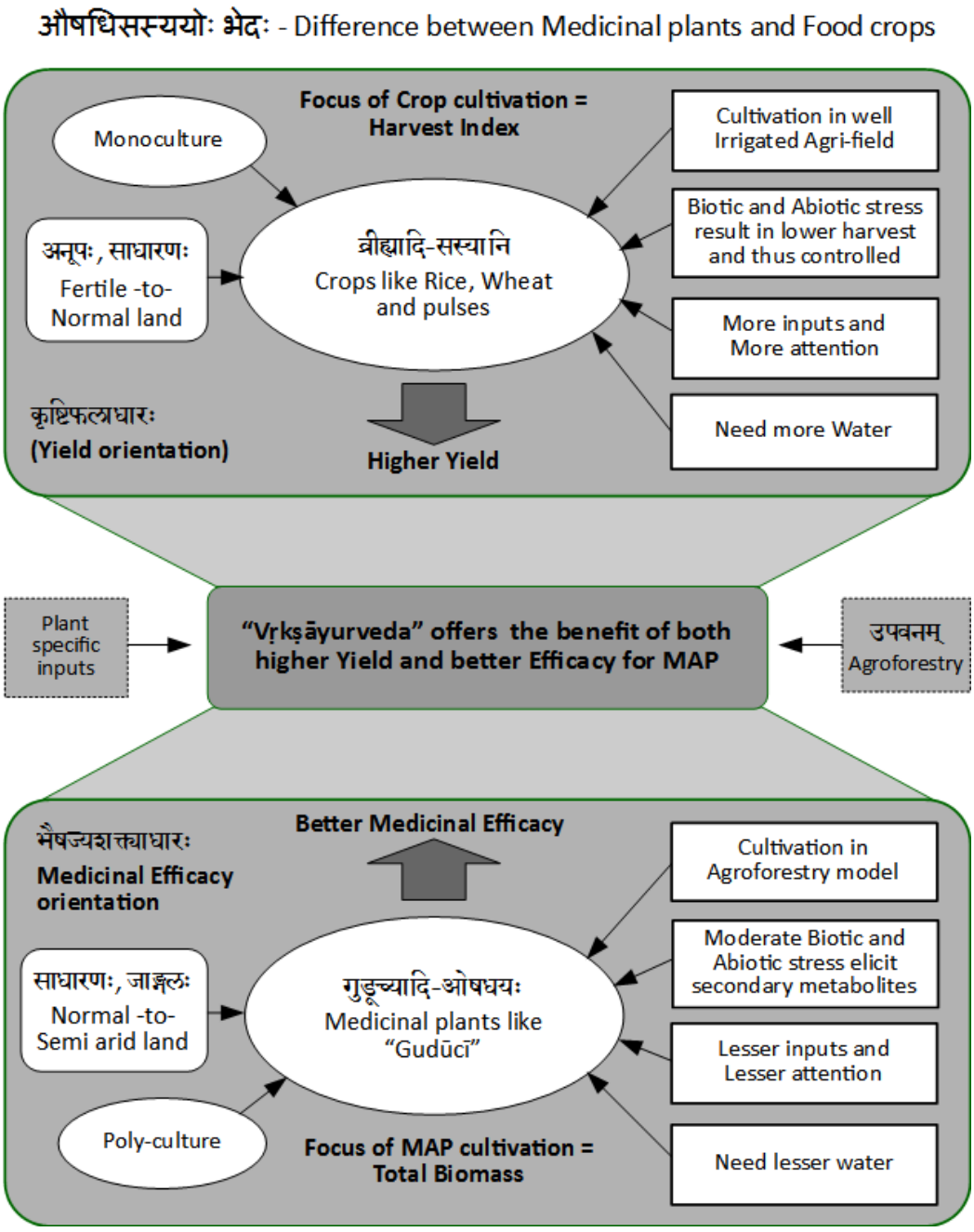

Figure No. 5.6 Differences in cultivation of Food crops and Medicinal plants

5.9 Harvest and collection of medicinal plant raw-material

Medicinal plants should be harvested during the optimal season or time period to ensure the production of medicinal plant materials and finished herbal products of the best possible quality. The time of harvest depends on the plant part to be used. Detailed information concerning the appropriate '*Sangraha-kāla'* (harvest timings) for medicinal plants and herbs are available in Ayurvedic texts such as '*caraka saṃhitā*' and '*suśruta saṃhitā*' and also in '*nighanṭu*' (materia-medica) texts such as '*bhāvaparakāśa-nighaṇṭu*', '*rāja-nighaṇṭu*', etc. The Ayurveda based '*Sangraha-kāla'* (harvest timings) are most suitable for Ayurvedic medicinal plants, herbs, aromatics and spices as they are determined based on the Ayurvedic medicinal efficacy /potency. Modern pharmacopoeias and herbal monographs also contain conditions for harvesting medicinal plants from botanical points of views.

Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity. If harvesting occurs in wet conditions, the harvested material should be transported immediately to an indoor drying facility to expedite drying so as to prevent any possible deleterious effects due to increased moisture levels, which promote microbial fermentation and molds. Concentration of biologically active plant chemicals, secondary metabolites constituents differ with the stage of plant growth and development and also the season of harvest

The best time for harvest with respect to quality of plant substances from an Ayurveda standpoint is given in a detailed manner in '*caraka saṃhitā*'. For Medicinal plants and herbs, peak season, month, day, time of day of

harvest are determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield.

It is also to be noted that with respect to Medicinal plants it is not only fruit /seed yield that is important but the complete biomass right from leaves to stems to flowers to roots, everything is important. Herbal medicinal formulations use the entire plant for drug making unlike food substance where the yield of seed /fruit is of importance.

During harvest, care should be taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials.

'*Arthasastra*'[145] advises harvested produce shall be collected completely after harvesting within the same day. Appropriate to the crop and produce harvested substances should be stored, reaped, piled, packed, threshed, dried, processed within the stipulated time and before the substances lose their potency bio-active ingredients.

'*Caraka saṃhitā*' advises various produce such as leaves, flowers, stems, barks, fruits, seeds and roots to be harvested according to plant types, seasons and plant maturity and are applicable to different geographical regions and also specific medicinal herbs.

[145] Arthasastra, sītādyakṣa II.2.15

5.10 Storage of Medicinal plants and herbal products

हस्ताहरित्रये पुष्ये रेवत्यां च प्रजापतौ ।
यममूलोत्तरे सौम्ये मघायां च पुनर्वसौ ॥
जीवे सौम्ये भृगोर्वारे निधने क्रूरवर्जिते ।
मीनलग्ने शुभे ऋक्षे धान्यस्थापनमुत्तमम् [146]॥

The days of the stars of '*hasta*', '*śrāvaṇa*', '*dhaniṣṭā*', '*puṣya*', '*revatī*', '*rohiṇī*', '*bharaṇī*', '*maghā*', '*punarvasu*' in Thursdays, Mondays and Fridays and the days when the sun is near the Pisces constellation, except for Saturdays and inauspicious days, storage of seeds can have begun.

General guidelines for the storage of medicinal products and herbs

- According to '*Caraka*-saṃhitā', the medicines should be preserved in wooden boxes. Boxes are selected based on the type of medicines to be preserved. Storage should be free from moisture, rain, and sunlight. The room should be made facing East or North directions. Storage should be free from Dust, moisture and viral free.
- Storage chambers should be smoked with Camphor, Cinnamon and Indian frankincense – '*Guggulu*'.
- Storage chambers can also be fumigated with powders of '*kālamegha*' (*Andrographis paniculata),* '*nimba*' (*Azadirachta indica),* '*viḍaṅga*' (*Embelia ribes),* '*nirguṇḍī*' (*Vitex negundo*), '*siddhārtha*' (*Sinapis alba)*
- Medicinal products storage boxes should be made of wood or clay containers with lids to prevent moisture and also entry of insects

[146] Kṛṣiparāśara 1.241-242

- Inside of the storage boxes should be made of cotton clothes to absorb moisture .
- The medicine storage room should be well cleaned and dry. '*Gandhavardhikā*' (aromatic incense) such as *'havana-sāmagri'* or '*daśāngam*'. '*Pūjā*' (traditional worship) should also be done every month.

5.11 Ayurveda and '*Vṛkṣāyurveda*'

5.11.1 Pharmacognosy ('dravya nāma-rūpa vijñānam')

Nomenclature, taxonomy, identification and harvest /collection parameters are of critical importance in wild collection of medicinal plants as well as cultivation. The nomenclature of flora, fauna and mineral substances found in Ayurveda texts, '*nighaṇṭu*' (materia-medica) texts, lexicons like '*Amarakoṣa*' and various *Vṛkṣāyurveda* texts and across different historical time periods and regions are similar and follow the convention of 7 types of naming as given in the famous materia-medica text '*Rājanighaṇṭu*'. These terminologies and synonyms are found in Sanskrit lexicons and dictionaries also.

नामानि क्वचिदिह रूढितः स्वभावात् देश्योक्त्या क्वचन च लाञ्छनोपमाभ्याम् ।
वीर्येण क्वचिदितराह्वयादिदेशात् द्रव्याणां ध्रुवमिति सप्तधोदितानि [147]॥

Medicinal herbs' nomenclature should be examined and identified according seven types naming including social convention, medicinal quality, geography, efficacy, identifying marks, examples, and other naming methods.

[147] Rājanighaṇṭu 1.13

हेतुलिङ्गौषधज्ञानं स्वस्थातुरपरायणम् ।
त्रिसूत्रं शाश्वतं पुण्यं बुबुधे यं पितामहः[148] ॥

As per the great sage (Agnivesha), the wise should gain knowledge of the three core branches of Ayurveda, (the base onto which other branches are established) and they are '*hetu*' (etiology), '*liṅga*' (symptoms) and '*auṣadha*' (medicinal formulations).

Ayurveda and *Vṛkṣāyurveda* being sister scientific disciplines, the role of *Vṛkṣāyurveda* in Ayurvedic healthcare system is critical. In particular the success of the therapeutic qualities of Ayurvedic formulations depend on the quality of the cultivated medicinal plants based on *Vṛkṣāyurveda.*

The subtle yet important contributions of *Vṛkṣāyurveda* towards Ayurvedic medicine's raw material is depicted in the Figure No. 5.7 next page

[148] Carakasaṃhitā, Sūtrasthānam 1.24

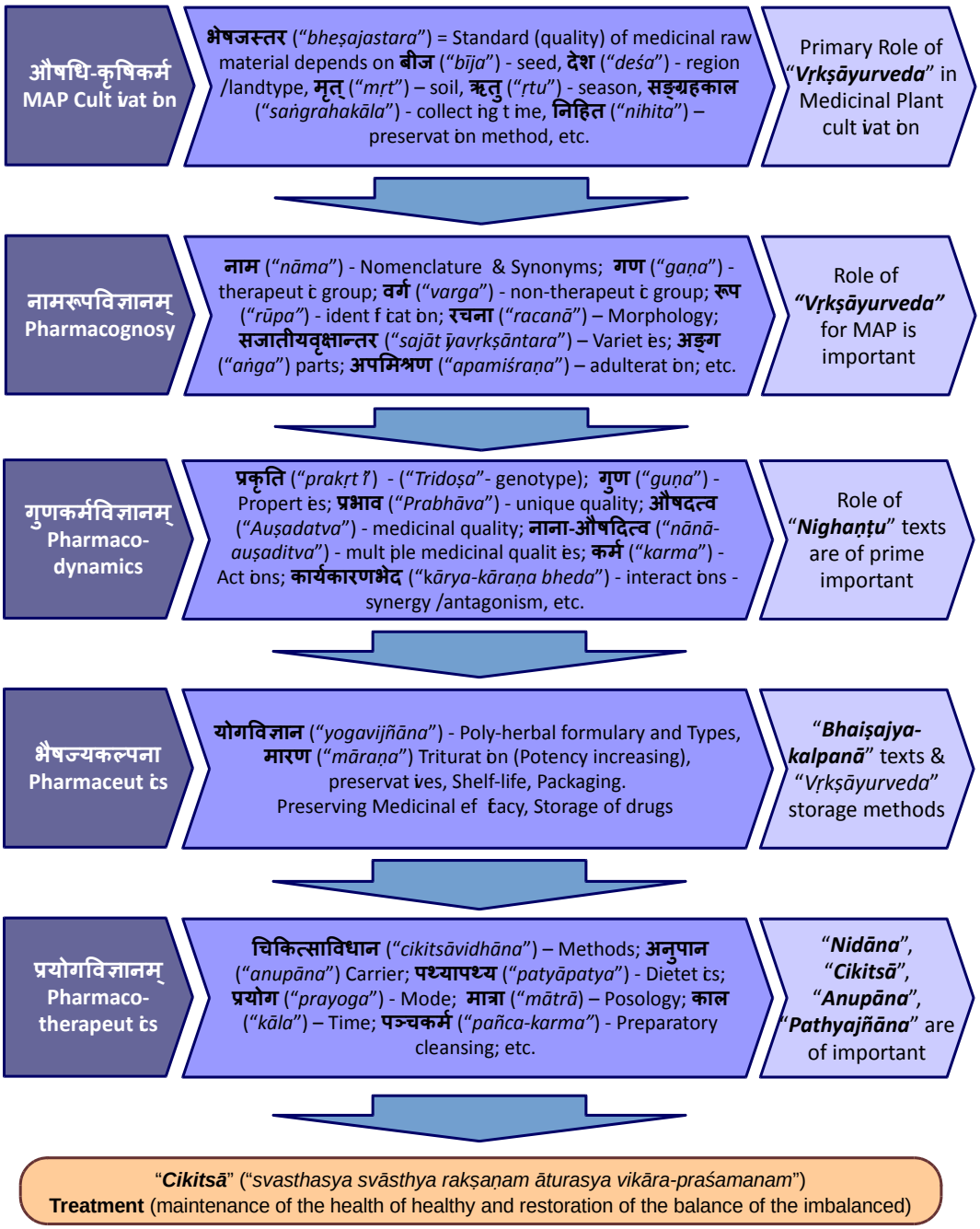

Figure No. 5.7 : Ayurveda and *Vṛkṣāyurveda*

Chapter 6: Medicinal plants cultivation in India – a critical outlook

Medicinal and aromatic plant cultivation faces many challenges in India. These include difficulties in Organic certification and also meeting the NMPB guidelines. The primary reason for this is the lack of awareness and capacity building initiatives at state and district levels across the nation. Medicinal plants need to be cultivated in Organic farming way, yet the cultivation methods differ for medicinal plants from that of other food crops.

However, both Organic farming of various crops and Medicinal plant cultivation have been steadily growing across India due to the high demand for Organic produce and Medicinal plants. Figure 6.1 highlights the growth of Organic farming and MAP cultivation in India by FiBL survey in 2018

Crop group	2015 [ha]	2016 [ha]	Change 2015-2016[ha]	Organic share [%]*
Cereals	3'889'488	4'091'183	+201'695	0.6%
Dry pulses	442'084	529'138	+87'054	0.6%
Flowers and ornamental plants	6'547	13'967	+7'420	-
Green fodders from arable land	2'506'919	2'760'550	+253'631	-
Hops	327	617	+290	0.7%
Industrial crops	9'877	16'205	+6'328	-
Medicinal and aromatic plants	110'436	182'579	+72'143	10.1%
Mushrooms and truffles	1'250	22'962	+21'712	-
Oilseeds	1'235'880	1'286'588	+50'708	0.6%
Root crops	49'079	90'287	+41'207	0.1%
Strawberries	5'985	9'196	+3'211	2.3%
Sugarcane	91'734	82'983	-8'751	0.3%
Textile crops	449'390	495'773	+46'383	1.5%
Tobacco	1'167	5'975	+4'808	0.2%
Vegetables	319'995	437'443	+117'447	0.7%
Total**	**9'985'785**	**10'612'350**	**+626'565**	**0.7%**

Source: FiBL survey 2018, based on information from the private sector, certifiers, and governments. For detailed data sources see annex, page 330
Not all countries included in the FiBL survey provided data on land use or crop areas.
**The organic crop group share is calculated with 2016 FAO data, while the organic share of total arable crops is calculated with 2015 FAO data.*
***Total includes arable crop groups for which no further details were available.*

Figure No. 6.1 Organic farming and MAP cultivation growth in India.

6.1 Contract farming of MAP

As on date over 80 companies are into contract farming with farmers across India for their uninterrupted supply of medicinal plants, aromatics and spices. Out of the 10,58,10,000 hectares (26,14,62,205 acres) of agricultural lands, only about 6,34,000 hectares (15,66,648 acres) are being used for Medicinal plant cultivation, which is roughly '0.6%' of the arable land.

6.1.1 Large contract farming entities:

The following large companies, including some of the large Ayurvedic drug manufacturers, are into producing raw materials for Ayurvedic drugs and nutraceuticals. These companies are sourcing their raw materials (Medicinal and Aromatic plants) through Contract farming. These companies also export Herbal drug raw-materials, semi-finished herbal products and herbal drugs and cosmetics. The size of the contract farming currently employed by each one of these companies is more than 100 acres. These farm-lands are exclusively used for cultivating a number of medicinal plants in Organic farming method.

1. Sami labs - 40000 acres in 14 states for MAP with 6500 farmers
2. Dabur (Ayurvet) - 5000+ acres in 19 states with 2400 farmers
3. Patanjali Ayurveda - 40000 acres in 8 states with over 3000 farmers
4. Himalaya herbals - 3500 acres in 6 states with 1200 farmers
5. Charak Pharma – Over 1200 acres in 3 states with over 500 farmers.
6. Kottakkal Arya vaidya sala (jointly with SAMI labs) – 2000 acres in 4 states with 650 farmers
7. Kerala Ayurveda – Over 5000 acres in 3 states with 900+ farmers.
8. Natural remidies – 1043 acres in 5 states with 420 farmers

9. Emami agrotech – 8000 acres in 4 states with 3000 farmers
10. Baidyanath (jointly with SAMI labs) - 3000 acres in 6 states with 1200 farmers
11. Hamdard labs (jointly with SAMI labs) – over 700 acres in 5 states
12. Nagarjuna Ayurveda – has over 800 acres in 3 states in contract farming through NMPB schemes with 400 farmers.
13. Pacific Agro (Maharashtra) - 2000 acres in Vidharba for Aromatics with 650 farmers
14. Natural Agro (Gujarat) - 900 acres in 3 states for MAP with 250 farmers
15. Arya Vaidya Sala (Coimbatore, TN) – over 300 acres in 2 states.
16. S. N. Pandit Ayurvedic Co., (Karnataka) – over 250 acres in 2 states
17. Zoic Pharmaceuticals
18. Surya Herbals Limited
19. Zandu
20. Vicco Laboratories
21. Divya Pharmacy

Other MAP contract farming companies

There are over 50 more medium and smaller size contract farming companies are operating across India. These companies are primarily involved in cultivation of Medicinal plants through contract farming, sourcing for non-cultivated medicinal plants from Mandis and Herbal plants markets, pre-processing, herbal drug processing and exporting.

In addition to the efforts of the contract farming companies involved in medicinal herbs contract farming, processing and herbal bulk-drug exports, there have been several instances of farmers moving towards the cultivation of medicinal plants across India. The state of Andhra pradesh, which had

about 5000 acres of MAP cultivation in 2016 has grown the area under MAP cultivation to 7200 acres in 2017. Similarly, in the state of Tamil Nadu the total area for MAP cultivation has increase by 12% from 2015 to 2017.

Punjab – Through farmers' cooperatives, Self-help groups and with help from State forest and wildlife department over 300 farmers in Pathankot district & Villages in lower Shivalik ranges have turned to MAP cultivation in 2017 with each farmer getting an average income of Rs. 70,000 – Rs. 80,000 per acre.

6.2 Medicinal herbs – Cultivation guidelines

Herbal medicinal products have to adhere to a number of guidelines and standards right from cultivation and sustainable wild collection of medicinal plants, to processing to packaging and storage, etc. These regulations and standards are proposed by various agencies both internationally such as WHO as well as trade-blocks like EU and specific countries. Internationally agreed quality evaluation of herbal raw-material consists of 1). Identification of the herb and herbal substance including the geography of the herb's cultivation, 2). Standardized classification of the herbal substances 3). Determination of the herbal substance's quality, attributes and purity including the quality of cultivation of the medicinal herb. This chapter highlights some of the herbal products guidelines and standards specific to the cultivation of medicinal plants. It is to be noted that *Vṛkṣāyurveda* being a natural /organic agricultural process which is also sustainable shall fully adhere to these cultivation guidelines and standards.

6.2.1 International standards on herbal medicines

ICH guidelines

International Conference on Harmonization (ICH) has published the guidelines of Technical Requirements for Registration of Pharmaceuticals for Human Use during early 2000s. All pharmaceutical products, both synthetic and herbal products need to adhere to the same.

Botanical source identification

GI (Geographical indication) – Tag for MAP and Spices and Harmonized commodity description and coding system (HS Code) for international trade of herbal products and herbal drugs

Omics:

'Omics' based quality control of herbal plants. Omics stands for, (proteomics, metabonomics, transcriptomics etc.), using these techniques it is easy to determine the pharmaco-dyanamics, pharmacokinetics and toxicological characterization of the active ingredient of a medicinal /herbal plant

6.3 WHO – Good Agricultural Practice Standards

The following is the abstract of WHO (World Health Organization) and FAO (Food and Agricultural Organization) joint standards of Agricultural and collection practices for Medicinal herbs called as GACP (Good Agricultural and Collection Practice) standards.

> *'Medicinal plant materials are supplied through collection from wild populations and cultivation.*

Under the overall context of quality assurance and control of herbal medicines, WHO developed the Guidelines on good agricultural and collection practices (GACP) for medicinal plants, providing general technical guidance on obtaining medicinal plant materials of good quality for the sustainable production of herbal products classified as medicines. These guidelines are also related to WHO's work on the protection of medicinal plants, aiming promotion of sustainable use and cultivation of medicinal plants.

The main objectives of these guidelines are to:

1. *contribute to the quality assurance of medicinal plant materials used as the source for herbal medicines to improve the quality, safety and efficacy of finished herbal products;*
2. *guide the formulation of national and/or regional GACP guidelines and GACP monographs for medicinal plants and related standard operating procedures; and*
3. *encourage and support the sustainable cultivation and collection of medicinal plants of good quality in ways that respect and support the conservation of medicinal plants and the environment in general.*

These guidelines concern the cultivation and collection of medicinal plants and include certain post-harvest operations.

Good agricultural and collection practices for medicinal plants are the first step in quality assurance, on which the safety and efficacy of herbal medicinal products directly depend. These practices also play an important role in protection natural resources of medicinal plants for sustainable use[149]*.'*

GACP standards include the following collection and cultivation practices –

[149] https://apps.who.int/medicinedocs/en/d/Js4928e/

- *Seeds and other propagation materials*
- *Propagation*
- *Cultivation or collection site*
- *Crop rotation at the site*
- *Cultivation*
- *Application of fertilizers, growth regulators, pesticides and herbicides*
- *Unusual circumstances that may influence the quality (including chemical composition) of the medicinal plant materials (e.g.: extreme weather conditions, exposure to hazardous substances and other contaminants or pest outbreaks)*
- *Harvest or collections*
- *All processing*
- *Transportation*
- *Storage*
- *Application of fumigation agents*

6.4 Evaluation of Herbal raw material and testing

Herbal evaluation methods for classifying drugs and formulations include, drug characteristics based on Microbial, Physical, Biological, and Chemical parameters. Figure 6.3[150] describes the various analyses of herbal substances and tests to determine the quality of herbal drugs including the agricultural inputs such as pesticides and herbicides used during the cultivation of herbs. It is to be noted that the Phytochemical and Residual analysis are parts of the testing are specifically done to determine the cultivation of medicinal plants

[150] ICH, GMP, GACP, OMICS and European standards of herbal drug testing

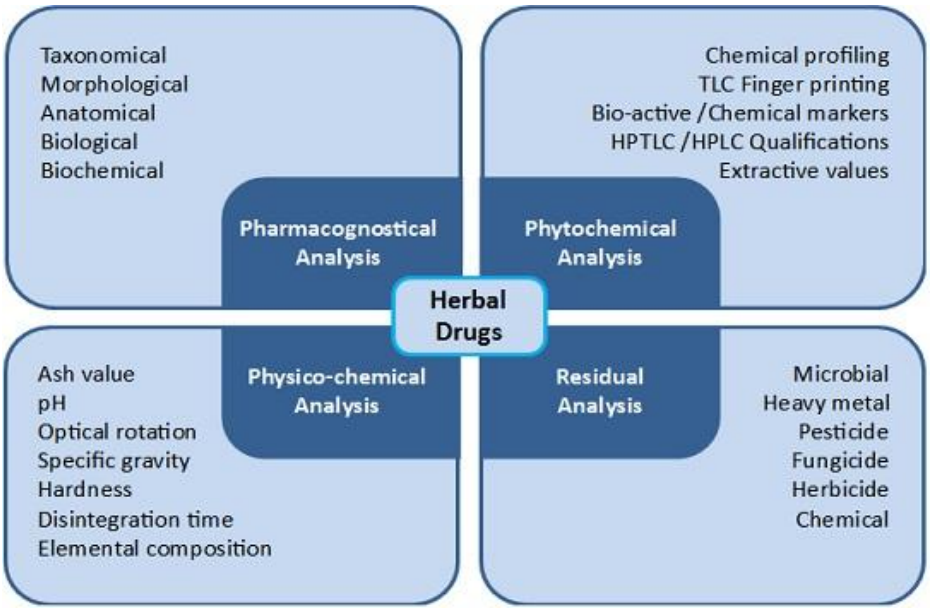

Figure No. 6.2 Herbal drug testing and analysis

6.5 Herbal medicinal products – Indian Standards and guidelines

6.5.1 ICMR Herbal database

Indian Council of Medical Research has published pharmacological monographs of 4706 medicinal plant species. Therefore, any modifications to the phytochemistry of the plants due to Generic engineering /Selective breeding shall cause non-compliance with respect to ICH (International Conference on Harmonization) Safety guidelines and also ICH Efficacy guidelines. Therefore, ICH propagates that genetically modified medicinal herbs are unsuitable for both cultivation and human consumption.

6.5.2 VCSMPP

Voluntary Certification Scheme for Medicinal Plants Produce (VCSMPP) of National Medicinal Plants Board (NMPB), Ministry of AYUSH, Government of India was launched in 2017 in order to encourage the Good Agricultural Practices (GAPs) and Good Field Collection Practices (GFCPs)

with respect to medicinal plants. The VCSMPP will enhance the availability of the certified quality medicinal plants raw material in the country and also boost their export and increase India's share in the global market for MAP.

6.5.3 PCIMH – Monographs:

Pharmacopoeia Commission of Indian Medicine and Homeopathy (PCIMH), Ministry of AYUSH, Government of India has published Plant pharmacopoeia monographs of 519 Ayurveda medicinal plants, 139 Siddha medicinal plants, 298 Unani medicinal plants. In addition to these, the Ayurvedic formulary of India (AFI), Ministry of AYUSH, Government of India has published 444 poly-herbal formulations of Ayurveda medicinal system. This pharmacopoeia and formulary data are available in the public domain for the usage of Pharmaceutical companies and raw drug manufacturers.

With continuous improvements in the laboratory equipment for herbal raw material, formulations and finished drug testing, etc. coupled with historical data of adulteration and contamination, it will be much easier to examine each shipment of the AYUSH (herbal) products. With the deployment of Machine learning and AI algorithms it is easy to dig deep in historical data with respect to all possible adulteration and /or contamination it is becoming easier to identify sub-standard herbal products due to bad manufacturing practices as well as due to poor agricultural practices.

Therefore, it is essential for the cultivation of Medicinal plants as prescribed by WHO-Good Agricultural Practices and also the management of Soil health and cultivation to prevent accidental contamination.

6.6 WHO and AYUSH benchmarks for Ayurveda practice

World Health Organization (WHO) jointly with the Ministry of AYUSH, Government of India is developing Benchmarks Document for Practice of Ayurveda, Panchakarma & Unani and International Terminologies Documents in Ayurveda, Siddha & Unani as part of its global strategy to strengthen the quality, safety and effectiveness of Traditional and Complementary Medicine (T&CM).

Development of this benchmarks document is included in the Project Collaboration Agreement (PCA) signed between WHO and Ministry of AYUSH, Government of India, on Cooperation in the field of Traditional and Complementary Medicine (T&CM) under WHO strategy on T&CM covering the period 2014-2023.

The consultation meeting of international experts (IECM) on the benchmarks for practice is a continuation of the Working Group Meeting (WGM), which has been happening since 2018.

The practice benchmark documents are expected to serve as international benchmarks for qualified practice of Ayurveda, and Unani. These benchmarks will also frame the safety requirements for practicing Ayurveda, Panchakarma, and Unani and provide qualifying criteria for practitioners of Ayurveda and Unani among addressing other details and nuances of medical practice.

These benchmark documents shall serve as reference to national authorities to establish and strengthen regulatory standards and ensure

practice of Ayurveda, Panchakarma, and Unani, and assure patient safety across the world.

The benchmark documents are expected to provide list of terminologies in the respective systems; their definitions (short or explanatory descriptions) including contextual meanings of the terminologies, classical usage of the terms with references to the definitions and their recommended English terminologies, synonyms, etc.

These documents shall cover terms related to basic principles, fundamental theories, human structure and function, diagnosis, pathology, patterns, and body constitutions, pharmacognosy, pharmacology, preparation of food and medicines, therapeutics, and preventive and health promotion interventions, and miscellaneous terms in the respective medical systems.

Over 90 International experts are being invited from nearly 30 different countries (Covering all six regions of WHO) including Japan, New Zealand, Malaysia, Singapore, Bangladesh, Nepal, Sri Lanka, India, Mauritius, Ghana, South Africa, Tanzania, UAE, Iran, Italy, Switzerland, Spain, Germany, Latvia, Austria, Denmark, Russia, Hungary, USA, Canada, and Argentina.

With increased acceptance and global practice protocols of Ayurveda it is only apparent that there will be increased demand for Ayurveda medicinal plants and herbal products. Therefore, the need for increase in cultivation of Ayurveda herbs is more than ever. *Vṛkṣāyurveda* methods of cultivation would ensure that the core of Ayurveda, which is the '*auṣadam*' (medicines) shall be taken care in best manner.

With the increasing awareness about the benefits of Ayurveda and the plant based herbal /natural products, demand for medicinal plants has increased multi-fold in the past 20 years. A study of Indian Medicinal and aromatic plants market in 2016-17 was conducted by Indian Council of Forestry Research and Education (ICFRE) along with National Medicinal Plants Board (NMPB), the gist of data is presented below, as given in annual report of Ministry of AYUSH 2017-18. In addition, the commercial data from Pharmaceutical Export Promotion Council of India (PHARMEXCIL), Ministry of Commerce., about the Indian Medicinal Plants market are also presented.

The key findings are given in chapter 1, section 5 (1.5):

6.7 Quantitative & Qualitative data of MAP market

- Of the total codified 2500 medicinal plants, 1178 medicinal plant species are only available as on 2014-15 and out of these, 252 Ayurveda medicinal plant species are traded in large quantities of more than 100 Metric Tons per year.
- The consolidated commercial demand of herbal raw material for the herbal healthcare in the year 2014-15 has been 5,12,000 Metric Tons with a consolidated total value of INR 70,000 Millions with 11% annual growth
- Exports of Herbal raw material, including extracts has been 1,34,500 Metric Tons in 2014-15 representing a value of INR 32,110 Millions
- Estimated Consumption by Domestic Herbal Industry has been 1,95,000 MT 2014-15 with a value of INR 19,500 Millions.

- In addition, an estimated 1,67,500 Metric Tons of Herbal Raw material are also bought and used by Rural /unorganized healthcare sector in 2014-15 representing a value of INR 16,750 Millions
- India's traditional medicine and herbal healthcare sector has over 8500 licensed herbal units and over 100 major Ayurveda, Siddha and Unani pharmaceutical companies. These companies are dependent on the steady availability and supply of raw-material of Medicinal plants
- India is also the world's second largest exporter of MAP after China. Together India and China account for over 65% world's herbal, medicinal and aromatic plant supplies with respect to Asian herbal raw-materials.
- As on date the combined man-power employed in the entire supply chain of traditional /herbal healthcare system right from medicinal plant cultivation, collection, storage, cleaning, pre-processing, transportation, processing, value addition, manufacturing, packaging, distribution, stocking, retail sales, etc. is estimated to be 8 – 10% of the total population of India. This highlights contributions of the economic sustainability of the traditional medicinal and healthcare sector in India

The ICFRE & NMPB report also highlights that due to the increasing demand for the export of medicinal plants, raw herbs, semi-finished herbal raw material and finished herbal medicines, etc., many of the uncultivated **medicinal plants have been starting to get cultivated.**

Due to sustained efforts by the National Medicinal Plants Board (NMPB), Ayurvedic /Herbal medicine manufacturers, in promoting medicinal plant

cultivation during the past 15 years and also due to widespread demand for herbal raw material, about **100 Medicinal plant species are currently being cultivated by farmers across India.**

The share of **cultivated medicinal plants has gone up to 40%** in volume terms. Despite cultivation of many Medicinal plant species, **over 60% of the total volume of 5,12,000 metric tons (2014-15), are still being collected from wild** in an unsustainable manner.

Indiscriminate and unsustainable collection of Medicinal plants from the wild is pushing many Medicinal plant species into the danger of extinction. Already several medicinal plants are in the Red list (critically endangered) as per published data from the ENVIS (Environmental Information System), Ministry of Forests and Environment, Government of India and also as per IUCN (International Union for Conservation of Nature).

6.8 Critical needs for the cultivation of MAP

The need for cultivation and preservation of MAP (medicinal and aromatic plant) species is critical for the, (1) the protection of germ-plasms of a wide variety of medicinal plants through regular cultivation, (2) the availability of QPM (quality propagation material – seeds et. al,), (3) the refinement of farming methods and standards through repeated cultivation, (4) sustainable harvest of medicinal plants, (5) evolving appropriate post-harvest management techniques of MAP and (6) protection of the medicinal efficacy of the cultivated MAP., etc. are critical and essential. Therefore, Medicinal plants need to be cultivated in large scale for overcoming various medicinal, ecological and agro-economic shortcomings as detailed below. *Figure 7.3 gives the gist of critical needs for cultivating MAP*

- **Herbal medicinal formulation supply chain issues** – shortage of one single medicinal herb /raw material can potentially disrupt the production of an entire formulation of a drug, which contains many other medicinal herbs. Due to the delay and /or non-availability of a single medicinal herb other medicinal herbs have to be used elsewhere or totally discarded, as the shelf-life of raw herbs are less than 12 months. Thus the availability or non-availability of a single medicinal herb can affect the costs and the entire supply-chain of a herbal medicinal formulation.

- **Arid land farming** – Over 70% of the Ayurvedic /Siddha herbs are grown in arid lands and require less water and less maintenance to cultivate. Therefore, medicinal plants cultivation is most suitable and profitable for majority of the Indian plains as most of the country receives less than 3000 mm rainfall per-year.

- **Economic benefits to Farmers** – Comparatively, cultivation of medicinal plants offer higher economic benefits to the farmers. Per-acre cultivation of high demand medicinal and aromatic plants offer is 80% - 90% better income than any other food or commercial crops. In addition, due to the need to grow MAP without any chemical inputs, the input costs are also very low. Growing medicinal plants in Agroforestry model also reduces water and labour needs due to better efficiency and lower maintenance. Thus medicinal plant cultivation offers better economic sense for the farmers in India.

- **Prevention of herbal raw material adulteration** – accidental and intentional adulteration due to non-availability, identification problems, different nomenclature, plant species similarity, similar habitat, mass collection of many species, unorganized handling, etc. are leading to serious quality issues in herbal drugs. Thus, these problems can be avoided with cultivation of medicinal plants.

- **Propagation of Quality Planting Material (QPM)** – Standardized Production, distribution and Propagation of QPM (seeds, seedlings & saplings) through various government bodies, members and partners can be done including Ayurveda /Siddha /Unani drug manufacturers such as…

  - **NMPB /SMPB** (National Medicinal Plants Board /State MPB) – *Ministry of AYUSH*;

  - **DMAPR** (Directorate of Medicinal and Aromatic Plants Research), **ICAR** (Indian Council for Agriculture Research), **IISR** (Indian Institute of Spices Research), **IIHR** (Indian Institute of Horticultural Research), **NCOF** (National Center for Organic Farming), **NPOP** (National Program on Organic Program), **NHB** (National Horticultural Board), **KVKs** (Krishi Vigyan Kendras), **AU** (Agriculture Universities) – *Ministry of Agriculture*;

  - **CIMAP** (Central Institute of Medicinal and Aromatic Plants) and **NBRI** (National Botanical Research Institute) – *Ministry of Science & Technology;*

  - **ENVIS** (Environmental Information System), **ICFRE** (Indian Council of Forestry Research and Education), **TBGRI** (Tropical

Botanical Garden Research Institute) – *Ministry of Environment, Forest and Climate change*.

- **SHEFEXIL** – Shellac and Forest products Exports Promotion Council

- **Protection of Safety and Medicinal efficacy of Medicinal drugs** – Medicinal drugs of Ayurveda /Siddha /Unani medicines vary in composition and medicinal properties, where the raw-material quality and medicinal efficacy determine the finished product efficacy. Degradation of quality of raw materials due to the total time taken right from collection from wild to herbal marketplace and then procurement, semi processing and finally to the actual manufacturing, reduce the medicinal efficacy and clinical effectiveness of Ayurveda, Siddha and Unani medicines. Through controlled and supervised cultivation of MAP, these problems can be largely avoided.

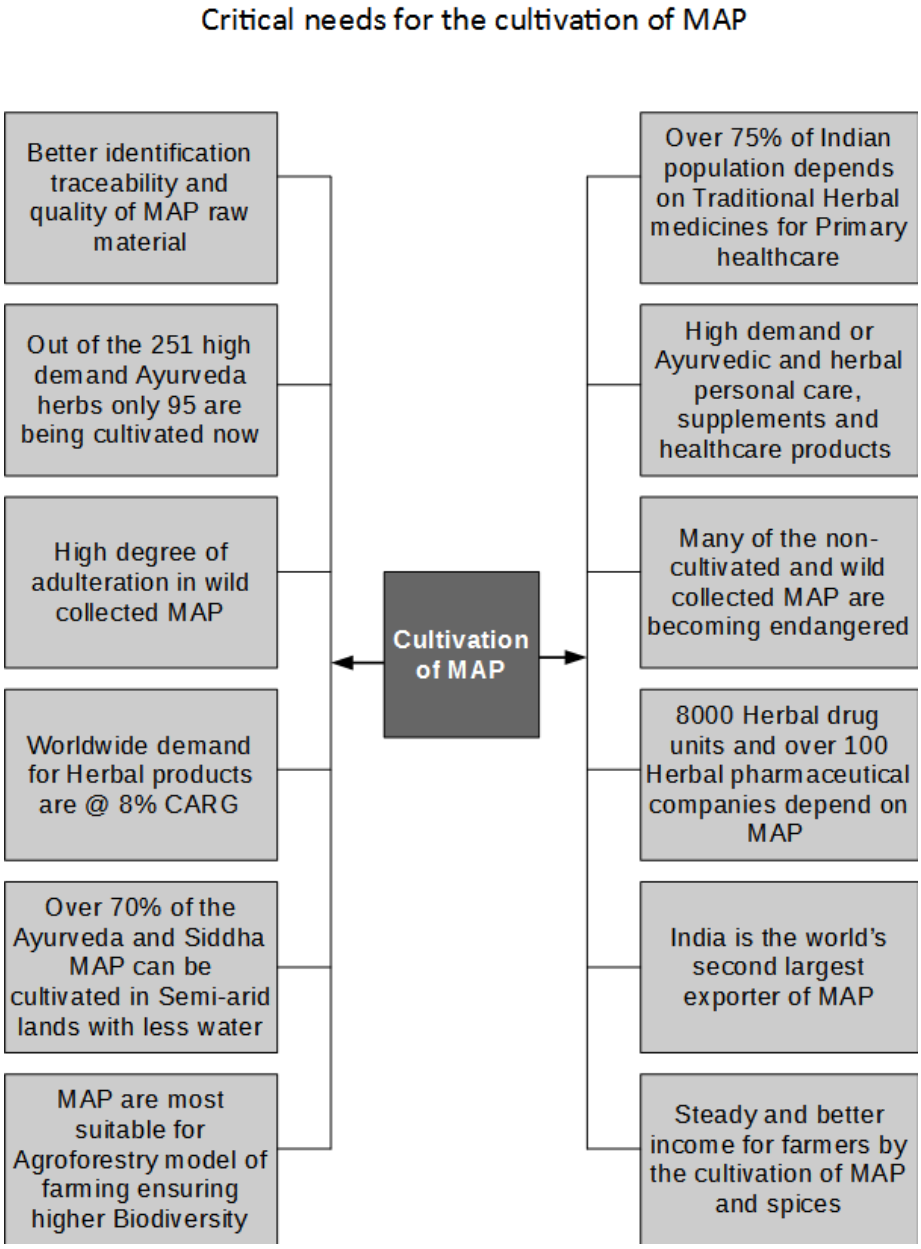

Figure No. 6.3 Critical needs for the cultivation of Medicinal plants

6.9 Issues in Cultivation of MAP

MAP cultivation offers the following issues with respect to quality, safety and standardization. These issues can be overcome with widespread cultivation of MAP through *Vṛkṣāyurveda* based methods and inputs.

1. **Lack of Cultivation protocols and training** – Several medicinal plants currently don't have for various non-cultivated medicinal plants. Even the ones which are currently being cultivated are done in a trial and error based way. Therefore, the need for establishing cultivation protocols and QPM nurseries for the widespread cultivation of MAP in addition to continuous training and training material for farmers on these aspects are essential.
2. **Pesticide residue** – Medicinal and aromatic plants are cultivated similar to other crops in agricultural fields with agro-chemicals such as fertilizers and pesticides. This results in contamination of the herbal drugs with the pesticide residues. World Health Organization (WHO), UN-Food and Agriculture Organization (FAO) and Food and medicine regulatory bodies in several countries including the USA do Phytochemical screening and testing for pesticide residues in Herbal drugs. Therefore, medicinal plants need to be cultivated without using Chemical fertilizers and Pesticides.

3. **Microbial contamination** – Lack of proper post-harvest management and pre-processing protocols for the medicinal plants such as segregation, cleaning, drying, sorting, and appropriate storage methods and infrastructure results in dampness. As a result, growth of microorganisms such as Fungi, Bacteria in herbal raw materials have

become common. This microbial contamination makes the herbal drug toxic as well as ineffective. Regulatory bodies of herbal medicines in most of countries have banned drugs which are found to have microbial residue. Thus the need for appropriate plant /herb specific post-harvest management and pre-processing protocols and storage mechanisms are necessary.

4. **Medicinal efficacy issues** – According to Ayurveda pharmacology, of non-compatible Chemical and/or Organic substances /residues can change the characteristics and medicinal efficacy of the herbal drugs. Therefore plant specific agricultural inputs including organic /botanical fertilizers and Organic pest repellents are necessary to prevent contamination of non-compatible substances in harvested medicinal plants.

5. **Quantity issues** – Need for huge quantities of a specific medicinal plant raw-material in short notice by the herbal pharmaceutical companies puts a lot of pressure to the MAP cultivars.
6. **Market price fluctuations –** Changes in market price of various herbal medicinal raw-material are too frequent and based on different seasonal, geographical and climatic conditions, in addition to quality of herbal raw-material.

7. **Standardization –** Lack of standardization of MAP commodity prices and also lack of uniform availability of MAP across the country.

6.10 Issues with wild collection of Medicinal plants

The primary issues in collecting medicinal herbs from the wild are:

Dependency on tribal collectors and agricultural middle-men – In the 20+ herbal '*mandi*' (whole-sale markets) across India, many of the agents and middle-men are not fully aware of differences in nomenclature and vernacular names for many of the medicinal plants. This results in identification and pharmacognosy problems. Many of the similar looking plants in-lieu of the actual medicinal plants are being sold. Also several different medicinal plants are having similar vernacular names and/or different names based on regional and linguistic variations. All these, lead to confusion in collection, trade and also commercial standardization of wild collected medicinal plants. Apart from the high-volume traded medicinal plants, many plants are not properly identifiable in the entire herbal drug supply chain.

Willful and /or accidental adulteration of medicinal plants with other similar looking and /or wild plants. These practices are widespread as it takes time to identify an herbal raw material, such as dried roots, leaves, stems and seeds for many of the MAP

Tribal communities lack pre-processing tools and techniques Wild collected medicinal plants don't undergo proper cleaning, air-drying /solar drying, sorting, stacking and appropriate packaging materials. Many times the wild collected herbal raw materials are contaminated with foreign bodies such as sand /soil and insect residues, biological contamination, etc. This results in toxicity and also reduces the shelf-life and quality of herbal drugs.

Unsustainable collection of medicinal plants such as uprooting of the entire plant, deeply cutting barks in trees without plastering /treating them with protective botanical support material for re-growth, lack of understanding the supporting plants, over collection leading to cross pollination issues, etc. are causing loss of rare medicinal plants, habitat loss, plant biodiversity issues, and eventually endangerment and extinction of many of the wild medicinal plants

6.11 Threats to medicinal plants

It is to be properly understood by everyone that the Medicinal plants are under multiple threats both natural and human made. Therefore, it is of prime importance to protect and conserve this invaluable natural wealth. Figure No. 6.4 in the next page pictorially highlights the threats to medicinal plants in the wild. It is therefore critical that large scale cultivation is essential to save medicinal plant wealth.

As per the survey done by NMPB and FRLHT in 2012, over 53 medicinal plants which are part of 100 Ayurveda and Siddha formulations are critically endangered

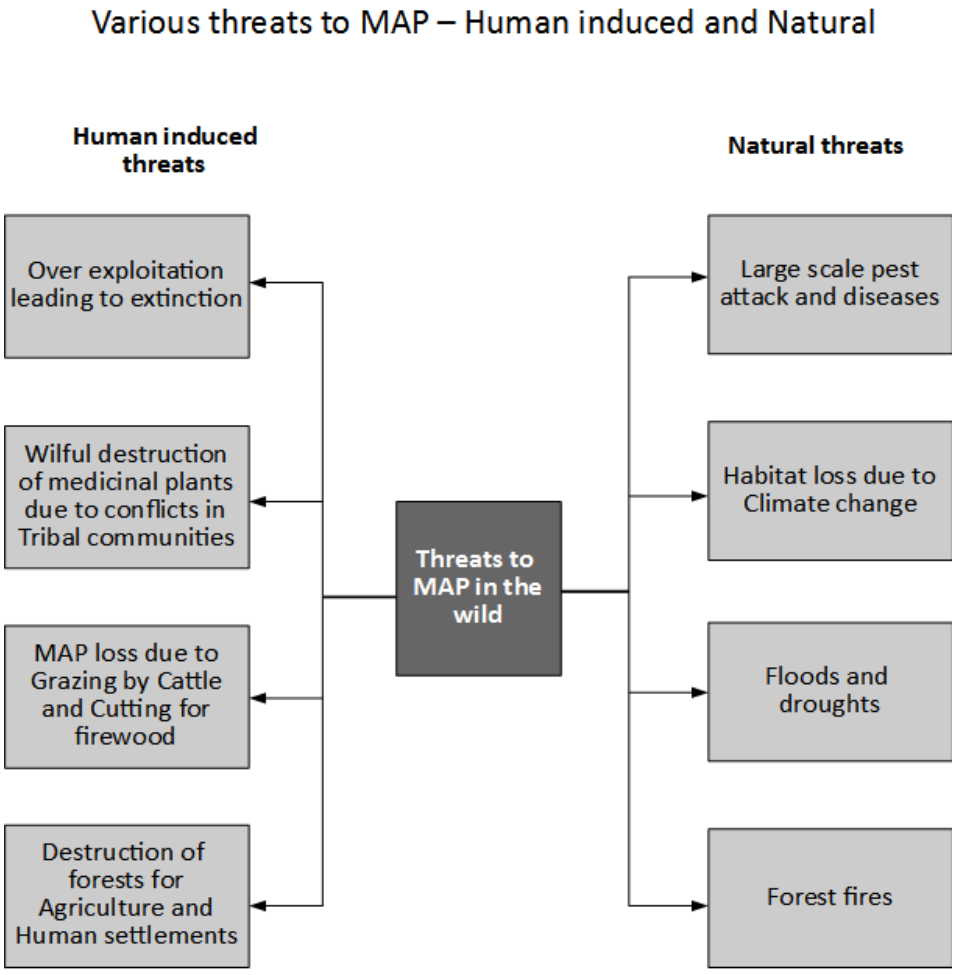

Figure No. 6.5 Threats to medicinal plants – Human and Natural

With widespread threat to medicinal plants both from human actions and natural calamities, it is therefore important for conservation and protection of medicinal plants in-situ and also their cultivation ex-situ towards long term protection and benefits for those plants which are under severe threat, to protect the natural herbal wealth.

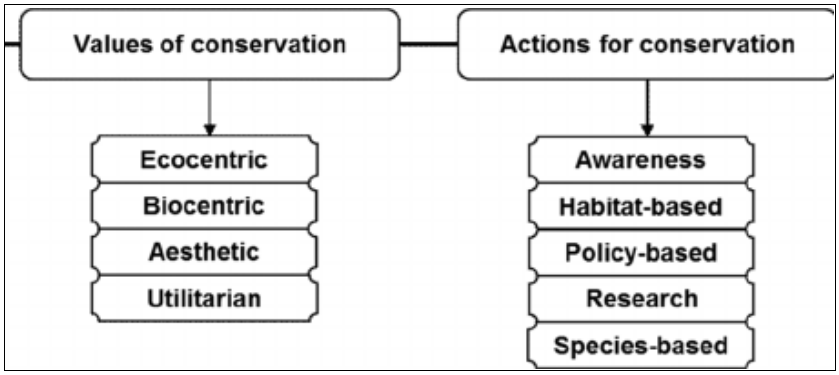

Figure No. 6.5: Medicinal plants conservation

Medicinal plants also get destroyed through forest fires which are started unknowingly and also willfully. Sometimes many are nearing extinction due over wild-collection. Therefore, awareness among general public needs to be created that Medicinal plants should to be cultivated in conditions which mimic the forest environments (Agroforestry) along with multiple other crops and medicinal plants to achieve both food security and health security.

During late 1990s, states of Karnataka, Tamil Nadu and Kerala started medicinal plants conservation project with FRLHT (Foundation for Revitalization of Local Health Traditions) and 34 MPCA (Medicinal plant conservation areas) were established. By the year 2006, they grew to over 110 MPCAs in 13 states in India. These MPCAs helped setting up over 20 district level medicinal gardens and 150,000 home medicinal gardens[151].

6.12 Plants are the primary source for Modern medicine and Drug research

The use of plants for medicinal purposes have long history. Several medicinal plants were used in many cultures for centuries in the treatment of

[151] Nimal Sengupta (2018), Traditional Knowledge in Modern India

various ailments. With respect to the modern medicine, initially the entire formulation was derived from Plant and other natural sources. Due to long history of plants for clinical use, due to their better tolerance, bio availability, social acceptance, several plant derived medicines are in use even in societies which have advanced synthetic pharmaceutical industry.

In entire healthcare industry it a widely accepted practice to derive at synthetic formulations based on reverse-pharmacology methods. Where the active principle, active ingredient or active molecule is isolated from a plant source and is mass-produced in laboratories. Using such methods, over 40,000 plant species have been screened for their medicinal use based on the knowledge gained from ethnic usage of plants for medicinal purposes. Plants especially those with ethno-pharmacological uses have been the primary sources of medicine for early drug discovery. Fabricant and Farnsworth, (2001) reported that, 80% of 122 plant derived drugs were related to their original ethno-pharmacological purposes. Such methods have led to the discoveries of important anticancer drugs such as paclitaxel, camptothecin, etc. Therefore, the Medicinal plant wealth need to be protected for the future survival of humanity.

Drug	Plant source	Clinical observation	Molecular mechanism of action
Artemether	Qinshausu	Chloroquin resistant malaria	Heme–mediated decomposition of endoperoxide, generating free radicals
Atropin	*Atropa belladonna*	Antispasmodic	MAch receptors
Caffeine	*Coffee Arabica*	Stimulant	Adenosine receptors
Cannabis indica	Indian Hemp	Sedation, antiemetic	Cannabinoid receptors
Cocaine	Leaves of Coca	Addictive drug	CB_1 CB_2
Colchicine	*Colchicum autumnale*	Relief of pain in gout	Blocks DAT, NET, SERT Inhibits release of leukocyte-derived chemotactic factors
Digitalis	Foxglove	Relief of dropsy	Na+K+ATPase
Emetine	Ipecacuana	Amoebic dysentery	Inhibits protein synthesis in eukaryotic cells
Ephedrine	Ephedra	Bronchodilator	α, β adrenoreceptor agonist
Eserine	Calabar beans	Pupil constriction	Reversible cholinesterase inhibitor
Morphine	*Papavarum somniferum*	Analgesic	Opioid receptors
Nicotine	Tobacco plant	Stimulant	Nicotinic Ach receptors
Quinine	Cinchona bark	Fever due to malaria	Inhibits hemozoin crystallization – aggregation of cytotoxic heme
Reserpine	Sarpagandha	Sedation, lowers BP	Blocks $VMAT_1$, $VMAT_2$
Salicylic acid	*Salix alba* Willow bark	Fever and pain relief	Cox inhibitor NFKB inhibitor
Strychnine	*Nux vomica*	Hyperexcitability convulsions	Blocks glycine receptors
Vincristine	*Vinca rosea*	Anticancer	Binds to tubulin disrupts microtubule assembly

Figure No. 6.6: Plant origin of some of the important modern drugs

The above figure 6.7 provides the details of some of the critical synthetic drugs which originated from plant sources. It is estimated that still over 60% (as of 2015) of bulk drugs are manufactured from plant sources. It is therefore critical that the herbal medicinal plants industry is well protected and grows to newer heights to enable protection of cost effective primary healthcare in developing countries as well as new drug discovery using reverse pharmacology methods[152].

[152] *Lele R. D., Dr., (Department of Nuclear Medicine and RIA, Lilavati Hospital and Research Center), Journal of Ayurveda & Integrative Medicine, October 2010, Vol 1, Issue 4*

Chapter 7: MAP cultivation protocols - *Vṛkṣāyurveda* based recommendations

As detailed in the previous chapters, this research is significant from the standpoint of

1). Cultivation of medicinal plants which are different from the cultivation of crops, vegetable and other commercial plants.

2). Identification of most suitable cultivation protocols for some of the high-demand medicinal plants from various *Vṛkṣāyurveda* texts

3). Methods that are Organic and natural with locally available inputs based on plants and animal byproducts.

4). Research and identification of *Vṛkṣāyurveda* methods which are based on '*upavana*' (Agroforestry) based cultivation for medicinal plants for the protection of ecology.

5). Identification of traditional methods and substances for growth stimulation, pest control and storage, which are farmer-friendly and also economically sustainable.

Through this research it is recommended that, the Ayurveda and herbal medicines using the cultivated medicinal herbs, which are produced based on *Vṛkṣāyurveda* based cultivation and storage methods shall have highest safety & medicinal efficacy.

7.1 Systems *Vṛkṣāyurveda*

This sub chapter highlights the approach towards mapping various natural and environmental phenomena with various processes of *Vṛkṣāyurveda.* This is modeled towards easy understanding of the processes of *Vṛkṣāyurveda* in addition to their interactions with natural and environmental variables in a systems biological model

The following Figure No. 7.1 provides the systems architecture of *Vṛkṣāyurveda* including distinctive processes and interaction with natural parameters. This is inspired and modeled based on 'Systems biology'. It is to be noted that the systems model represents a cohesive group of interrelated and interdependent part which are both natural as well human interventions providing a holistic view of agriculture in a systems biology model. Influenced both by natural phenomena and human interactions.

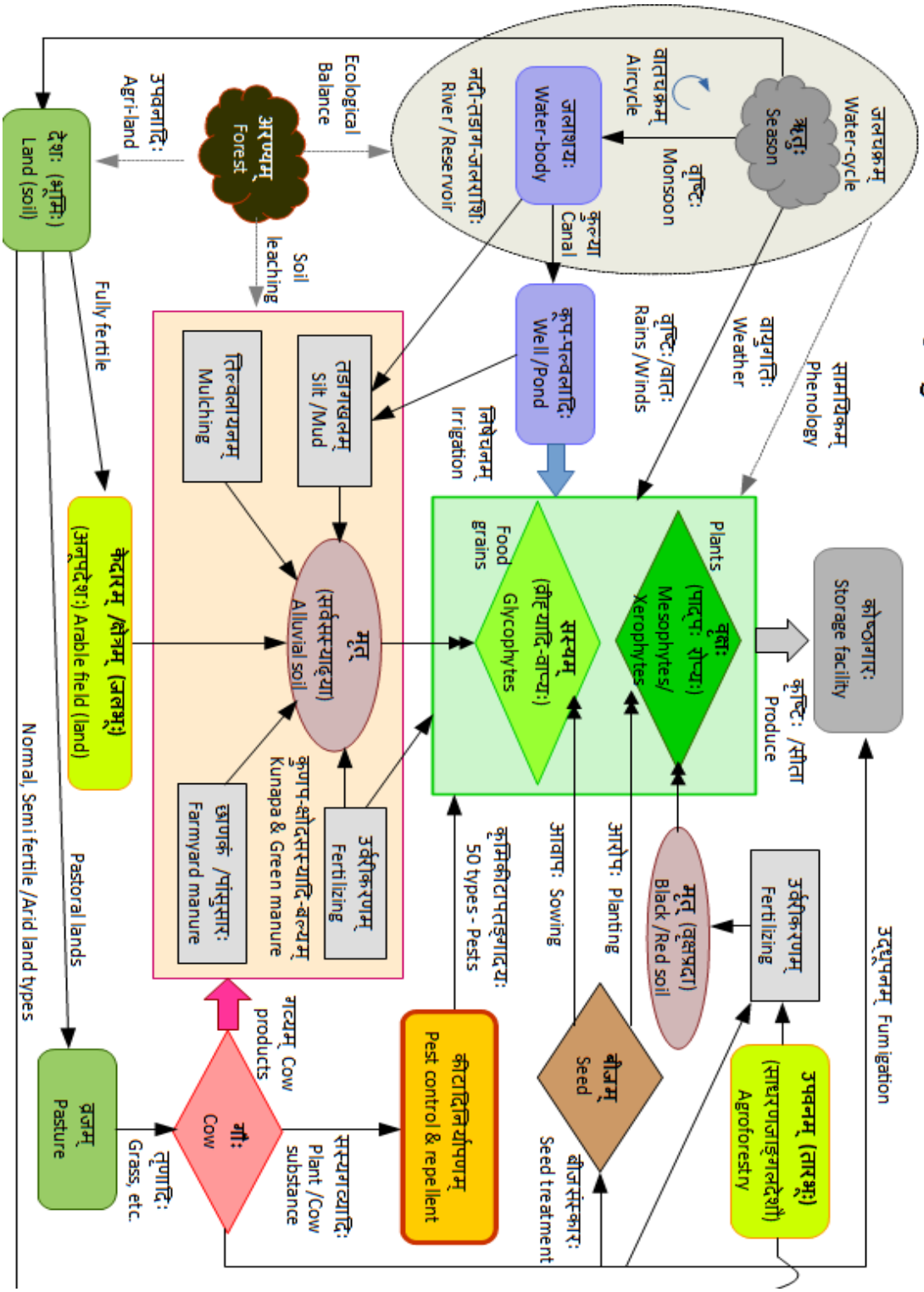

Figure No. 7.1 - Systems architecture of *Vṛkṣāyurveda*

7.2 Qualitative needs of various stakeholders

Cultivation of medicinal plants including the down-stream usage in healthcare involve several challenges. Some of these challenges are meeting the qualitative needs of various stake holders in terms of quality, efficacy and availability of the herbal medicinal products. Some of these needs of herbal medicinal products, such as doctors, pharmacologists, regulators and farmers are diagrammatically represented in Figure 7.1 below.

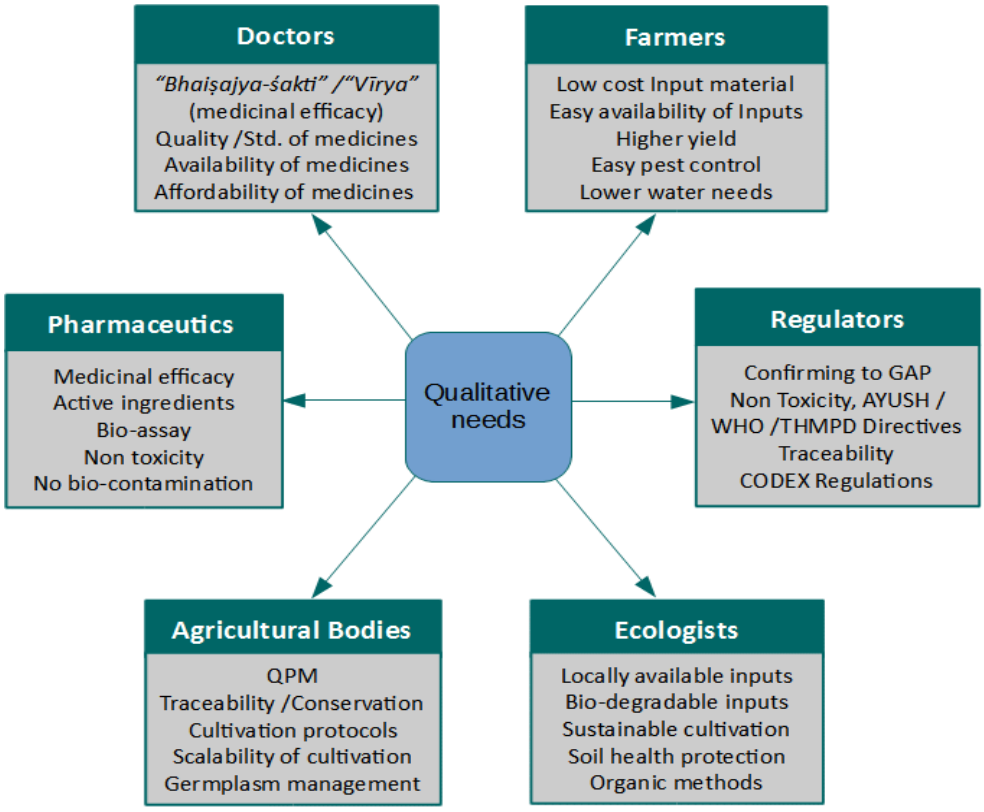

Figure No. 7.2 – Qualitative needs of various stakeholders from Herbal medicinal products.

7.3 Seed treatment recommendations based on types

Different type of plant requires different type of planting methods to grow and yield good results. Quality planting materials (QPM), such as seeds, rhizomes, stem-cuttings, saplings, etc. need to be treated - such as soaked, dipped and dried before they are planted in the prepared soil. The following table below provides the methods and substances for generic seed treatment which are recommended based on *Vṛkṣāyurveda* methods to prevent both diseases as well as common pests

Medicinal herbs (Seeds -QPM)	**Diseases**	**Pests**	**Seed (QPM) treatment - *Vṛkṣāyurveda* methods**
Rhizomes	Root rot, Wilt Bacterial sheath blight, Soil and Tuber-borne diseases	White tip nematode Root knot nematode	Soaking in '*kuṇapa-jala*' and '*vidanga*' (Embilica ribes) mixture,
Tree (seeds, saplings and stem cuttings)	Leaf blight	Soil borne pest attack	Pit preparation with burning the pit and also smearing the pit with ash. Pot soil for seed planting should be prepared with Cow-dung manure, '*kuṇapa-jala*', '*vidanga*' (Embilica ribes), etc. Seeds to be soaked for 2-3 hours in '*kṛṣṇaśirīṣa*' (Albizia amara /lebbeck)
Seeds of Shrubs, Creepers and climbers and herbs	Anthracnose spp. Damping off Fungal diseases Early blight Wilt White rot	Stem borers, Soil borne pests, aphids, thrips, etc.	Seed & Sapling dipping in milk and '*kuṇapa-jala*'. Seed pelleting and besmearing with honey, cow-dung, clay, etc. Drying seeds in Sun-light ('*uṣṇa-śoṣaṇa*') and mist ('*tuṣārapāyana*') for seeds, etc.

Table No. 7.1 – Seed treatment in *Vṛkṣāyurveda*

7.4 Agroforestry – Recommendations for MAP cultivation

The following table provides the list of medicinal plants that are currently growing and mapped with the *Vṛkṣāyurveda* based land classifications and altitude. This list serves as a template for setting up of MAP Agroforests. The list is provided in the Table No. 7.2 below

Soil /Land type & Altitude	**अनूपः Wetland**	**साधारणम् Normal land**	**जाङ्गलम् Semi-Arid land**
गिरिप्रदेशः Highland/Hilly (Above 1000 Mts.)	Kumkum (Kesar) Teak Parushaka Sveta-mushali Cardomum Pine Pushkarmool (Inula racemosa) Kutki (Picrorhiza kurrooa) Kuth (Sassurea costus)	Jatamamsi Kumkum (Kesar) Cardomum Daru-haridra Shaalaparni Wolf-berry Teak Vidanga Shallaki (Boswellia serrata)	Guggulu Arjuna Neem Shankapushpi Daru-haridra Acacia Sarpagandha Paeonia officinalis
शैलप्रस्थः Medium Elevation (500 - 1000 Mts.) and समाः (plains)	Ginger Turmeric Ashvagandha Sveta-mushali Jati Pepper Long pepper Tail pepper Coconut Brahmi Shalaparni Jatamamsi Sarpagandha Teak Spices /Aromatics	Amla Guduchi Turmeric Pomegranate Seetaphalam Arjuna Brahmi Mandukaparni Shaalaparni Safflower Daru-haridra Sarpagandha Citrus Teak Vidanga Spices /Aromatics	Amla Gokshura Guduchi Pomegranate Arjuna Guggulu Seetaphalam Tulasi Daru-haridra Aloe vera Neem Sarpagandha Shankapushpi Acacia Carissa carandas Liquorice

उपत्यका Lowland (Below 500 Mts.) and समाः	Ginger Turmeric Ashvagandha Guduchi Sveta-mushali Jati Pepper Long pepper Tail pepper Galangal Sarpagandha Citrus Gurmar (Gymnema sylvestre) Spices /Aromatics	Amla Ginger Turmeric Ashvagandha Mango Pomegranate Guduchi Agastya Safflower Galangal Daru-haridra Neem Citrus Gurmar (Gymnema sylvestre) Spices /Aromatics	Amla Ashvagandha Ginger Turmeric Guduchi Pomegranate Tulasi Mango Agastya Moringa Daru-haridra Aloe vera Neem Nannari Acacia
वेला Coastal Area (Below 100 Mts.)	Pepper Long pepper Tail pepper Guduchi Coconut Areca nut Bala Galangal Citrus Lemon grass	Coconut Areca nut Pepper Long pepper Tail Pepper Bala Guduchi Agastya Galangal Neem Moringa Citrus	Groundnut Bala Agastya Moringa Aloe vera Kundali /Peechangu /Sankuppi Nannari *Casuarina* equisetifolia Aloe vera Cassia fistula

Table No. 7.2 – Intercropping of MAP in Agroforestry model

7.5 Soil types in India and MAP recommendations

The following table No. 7.3 provides the recommended medicinal and aromatic plants that are suitable for various soil types in different regions and states in India.

Soil type	Consistency	Distribution	Major crops	Medicinal plants
Alluvial soil	Silty /Peaty	Ganga belt (UP, Bihar, WB, etc.)	Sugarcane, Banana	Musali, ashvagandha, punarnava,
Sandy soil (desert)	Sandy soil	RJ, GJ	Pulses, Mustard, etc.	guggulu, hingu, arjuna, kutki, etc.
Black soil	Clayey soil	East MH, TS, etc.	Cotton, Millets, Tobacco, Jowar, etc.	Tulasi, Guduchi Kalamegha, Aloe vera, etc.
Red /brown soil	Loamy soil	TN, KA, MH, AP,	Sugarcane, Corn, Mango	Amla, shatavari ashvagandha, etc.
Gray /Brown soil	Slightly saline soil	Semi arid parts – Deccan, MP	Cotton, oil seeds	Tulasi Kalamegha, moringa, etc.
Laterite soil & mountain soil	Loamy soil	Hilly regions of KA, KL, Assam	Coffee, Rubber, Cashew, Tea, Tapioca	Areca nut, Pepper, Tail pepper

Table No. 7.3 Soil types and the recommended medicinal plants

7.6 *Vṛkṣāyurveda* based inputs and the improvement in active ingredients (medicinal efficacy)

Several experiments have been done in the past decade on the usage of *Vṛkṣāyurveda* based inputs and methods for the cultivation of various food grain crops and vegetable crops such as Paddy, Mung bean, Brinjal, Tomato, Okra, Peas, etc. The results of the experiments have been very positive and encouraging. All of these research articles are published in peer-reviewed journals and are available for open access in the Internet.

Similarly, the following published research reports highlight the effects of '*kuṇapa jala*' and other '*Vṛkṣāyurveda 'inputs* for growing Medicinal plants with details on the medicinal efficacy (active principle and active ingredient) of the grown medicinal plants based on laboratory testing. The details are given in the table 7.3 below

Researcher	Medicinal plant, Research and Results	Publication
Gireesh M. Ankad, Jagadishchandra Hiremath, R.T. Patil, H.J. Pramod, Harsha V. Hegde 2017	**Research**: Nutrient analysis of Kunapa jala and Pancha gavya and their evaluation on germination of Ashwagandha (Withania somnifera Dunal) and Kalamegha (Andrographis paniculata Nees.) seeds: A comparative study Vrikshayurveda, has clearly outlined a systematized agricultural practice that insisted the use of Kunapa jala (KJ) and Pancha gavya (PG). The nutrient contents and germination parameters of KJ and PG were compared with other groups namely control (CONTR), farmyard manure (FYM), humic acid (HA) and NPK. **Results**: The pH and EC were 5.793, 2.653 dS/m and 5.584, 2.216 dS/m for KJ and PG respectively.	Journal of Ayurveda and Integrative Medicine, 2017

	KJ possess highest nutrient contents followed by PG. The germination parameters revealed the better activity of NPK followed by KJ, PG, HA, FYM and CONTR. KJ and PG were found to be good in nutrient contents and were found to be effective on studied germination parameters of Ashwagandha and Kalamegha seeds	
Asha KV 2006.	**Research**: '*Lāṅgalī*' (*Gloriosa superba* Linn.), Comparative pharmacognostic and pharmacological evaluation of Langali grown with Kunapajala **Result**: *Kunapajala* treated *'lāṅgalī'* plants exhibited excellent result in terms of general growth of the plants and fruiting when compared to control group and chemical fertilizer group. Even though the yield of tuber was not significant enough, one of its active ingredient 'Colchicine' (methanol extract) was found in higher amount in *Kunapajala* treated plants.	Ph D. Thesis, Gujarat Ayurved University. Jamnagar, India.
Brajeshwar 2002	**Research**: 'Effect of different agronomic practices on Senna (Cassia angustifolia Vahl.)' **Result**: Senna (Cassia angustifolia Vahl.) was grown by using both laboratory prepared and commercial Kunapajala. It was sprayed at the rate of 2 ml. per litre of water. Readings taken after 45 days of sowing showed significant results in parameters like height of the plants (in centimeters), enhancement of leaf area index etc. Leaves being the main organ containing Sennoside, the active ingredient, Kunapajala was helpful in substantially increasing it. The study also showed that fertilizer treated plants flowered very early but Kunapajala treated plants have delayed flowering resulting in harvesting of more foliage. Total Sennoside content per plant (in grams) was	M.Sc. Dissertation, Gujarat Ayurved University, Jamnagar, India

	analyzed after 70 days which showed that Senna grown using laboratory prepared Kunapajala showed excellent results when compared to chemical fertilizer and control group.	
Vijayalakshmi, 1997	**Research**: Enhancement of growth and flowering in Balsam *(Impatients sultana)* was studied after applying *Kunapajala* decoction. **Result**: The results showed that the response to *Kunapajala* was found favorable in all three stages of application i.e. germinative, vegetative and flowering stages	Compas CIKS Journal
P. Srimathi, N. Mariappan, L. Sundaramoorthy and M. Paramathma 2013	**Research**: 'Efficacy of Panchagavya on seed invigoration of biofuel crops' **Result**: Jatropha curcas and Pongamia pinnata seeds fortification with Panchagavya at 2 and 5% for 16 and 8 h, respectively of soaking had highest invigoration effect than water soaking and control. Thus, this study may suggest that Panchagavya application is one of the traditional, ecofriendly and low cost technique to enhance the better seed invigoration and promote the successful large scale afforestation in tree species.	AAHF, Academic Journals,

Table No. 7.4 - *Vṛkṣāyurveda* based inputs and medicinal efficacy

7.7 Harvest season recommendations for best medicinal efficacy in herbs

The following table highlights the most suitable harvest seasons for various herbal plant parts for achieving best medicinal efficacy from various Ayurvedic texts. Ayurvedic medicines are prepared predominantly based on text Bhaishaya ratnavali which is the recent one among many texts and therefore harvesting accordingly is recommended.

	***Caraka*-saṃhitā**	***Suśruta*-saṃhitā**	***Raja*-*nighanṭu***	***Bhāva*-*prakāśa*-*nighanṭu***	***Bhaiṣajya*-*ratnāvalī***	**Suitable Medicinal plants**
'*Mūla*' (Root)	'*Grīṣma*', (Summer) '*Śiśira*' (Cold)	'*Prāvṛṭ*' / '*varṣa*' (Rainy)	'*Śiśira*' (Cold)	'*Śiśira*' (Cold)	'*Grīṣma*' (Summer), '*Śiśira*' (Cold)	**Aśvagandha, Punarnava, Muśalī, Haridrā, Ārdraka, etc.**
'*Patra*' (Leaf)	'*Varṣa*' (Rainy), '*Vasanta*' (Spring)	'*Varṣa*' (Rainy)	'*Śiśira*' (Cold)	'*Grīṣma*' (Summer)	'*Varṣa*' (Rainy), '*Vasanta*' (Spring)	**Tāliśa, Tamāla, Tulasī, etc.**
'*Śākha*' (Stem)	'*Varṣa*' (Rainy), '*Vasanta*' (Spring)	--	--	--	'*Varṣa*' (Rainy), '*Vasanta*' (Spring)	**Gudūcī, Yaṣṭimadhu, etc.**
'*Puṣpa*' (Flower)	'*Yathā-ṛtu*' (as per season)	--	'*Vasanta*' (Spring)	'*Vasanta*' (Spring)	'*Yathā-ṛtu*' (as per season /full growth)	**Dhatakī. Japākusuma, Mallikā, etc,**

'***Phala***' **(Fruit)**	'*Yathā-ṛtu*' (as per season)	'*Grīṣma*' (Summer)	'*Vasanta*' (Spring)	--	'*Yathā-ṛtu*' (as per season /full growth)	**Āmalaki, Haritakī, Vidaṅga, Jātiphala, Paruṣaka, etc.**
'***Sāra***' **(Sap)**	'*Hemanta*' (Autumn)	'*Vasanta*' (Spring)	--	'*Yathā-ṛtu*' (as per season)	'*Hemanta*' (Autumn)	**Asana, Khadira, etc.**
'***Tvak***' **(Bark)**	'*Śaraḍ*' (Winter)	'*Śaraḍ*' (Winter)	--	--	'*Śaraḍ*' (Winter)	**Nimba, Dāruśita, etc.**
'***Kanda***' **(Rhizome)**	'*Śaraḍ*' (Winter)	--	'*Hemanta*' (Autumn)	--	'*Śaraḍ*' (Winter)	**Varāhi, Sūraṇa, etc.**
'***Kṣīra***' **(Latex)**	'*Śaraḍ*' (Winter)	'*Hemanta*' (Autumn)	--	--	'*Śaraḍ*' (Winter)	**Snuhi, Arka, etc.**
'***Pañcāṅga***' **(Whole plant)**	--	--	'*Śaraḍ*' (Winter)	'*Śaraḍ*' (Winter)	'*Yathā-ṛtu*' (as per season /full growth)	**Bhṛṅgarāja, Brahmī Nityakalyāṇī, etc.**

Table No. 7.5: '*Sangraha-kāla*' (harvest /collection) of medicinal plant parts for best medicinal efficacy

7.8 Storage of herbal raw materials and medicinal products

The contemporary storage mechanisms offer safe storage methods to prevent biological and chemical contamination of herbal products. Figure 5.8 below, highlights the storage recommendations of various herbal medicinal products with respect to various pharmaceutical processes and tasks which ensure safety, protection of medicinal efficacy and longer shelf-life.

Figure No. 7.3: Storage of medicinal products

7.9 Recommended cultivation protocols (partial) for NMPB ten high-priority herbs

The following tables No. 7.6 and 7.7 provide the recommended cultivation protocol based on *Vṛkṣāyurveda* methods with respect to Planting season, Soil type, Land type, Seed treatment methods, Manure, Pest control substances and Harvest time, etc. in a consolidated manner.

Sl. No.	Medicinal plant	Botanical name	Planting Season	Soil type	Land / Field
1	jatāmāṃsi	Nardostachys jatamansi	June - July	Black /Red /Brown	sādhāraṇa, anūpa
2	guggulu	Commiphora wightii	Jan - Feb	Brown /Red	jāṅgala
3	jīvantī	Leptadenia reticulata	All	Black /Brown	sādhāraṇa, anūpa
4	agar	Aquilaria agallocha	All	All (except marshy)	jāṅgala
5	raktacandana	Pterocarpus santalinus	June - July	All (except marshy)	sādhāraṇa, jāṅgala
6	aśoka	Saraca asoca (Roxb.)	Jan - Feb	All (except marshy)	sādhāraṇa
7	kirāta tikta	Swertia chirata	Mar -Apr Transplant	Rich /Black /Brown	sādhāraṇa, jāṅgala
8	dāruharidrā	Berberis aristata	Oct - Nov	Rich /Black /Brown	sādhāraṇa
9	śyonāka	Oroxylum indicum	July - Aug (transplant)	Rich /Black /Brown	sādhāraṇa, anūpa
10	sarpagandha	Rauwolfia serpentina	Oct - Nov	Rich /Wet /Brown	sādhāraṇa, anūpa

Table No. 7.6 Cultivation protocol-1 for Ten High priority MAP

Sl. No.	Seed and Seed treatment	Manure	Pest control	Harvest time
1	Stem cuttings, Cut portion to be applied with Cow dung, honey and ghee	Kunapa jala, Panchagavya	Snuhi-milk diluted, Vidanga	Varsha, Shishira
2	Seed soaking in milk & Albizia amara for 15 minutes, pit with Cow dung & ash	Cow dung, Kunapa jala, Panchagavya	Neem and Turmeric	Hemanta
3	Seed /seedling oaking in milk & Albizia amara for 15 minutes	Green & Ash, Panchagavya	Triphala, Snuhi, Panchapallava	Sharad
4	Besmearing with Cow dung, honey, ghee and Planting pit with Cow dung and Ash	Cow dung compost, Kunapa jala	Neem cake, Panchatikta	Sharad
5	-Same as above-	Cow dung compost	Neem and Turmeric	Sharad
6	-Same as above-	Cow dung compost, Kunapa jala	Pachatikta, Panchapallava	Sharad
7	Seed /seedling soaking in milk for 15 minutes	Panchagavya, Green	Snuhi-milk diluted, Vidanga	Sharad
8	Kunapajala & Albizia amara soaking	Panchagavya, Kunapajala, Snuhi	Neem, Vaca, Siddhartha, Vidanga	Sharad
9	Seed soaking in Milk and besmearing in Cow dung powder	Kunapa jala, FYM, Green manure	Vidanga, Vaca, Neem	Sharad
10	Cut portion to be applied with Cow dung, honey & ghee	Panchagavya, Kunapajala	Neem, Vaca	Varsha, Shishira

Table No. 7.7 Cultivation protocol-2 for Ten High priority MAP

7.10 Integration of *Vṛkṣāyurveda* with modern methods

The following Figure 7.4 provides the self explanatory model of integrating the time tested *Vṛkṣāyurveda* methods with the technology oriented modern methods. This model is recommended for the complete end-to-end lifecycle of Medicinal plant cultivation to achieve best results in both yield as well as medicinal efficacy

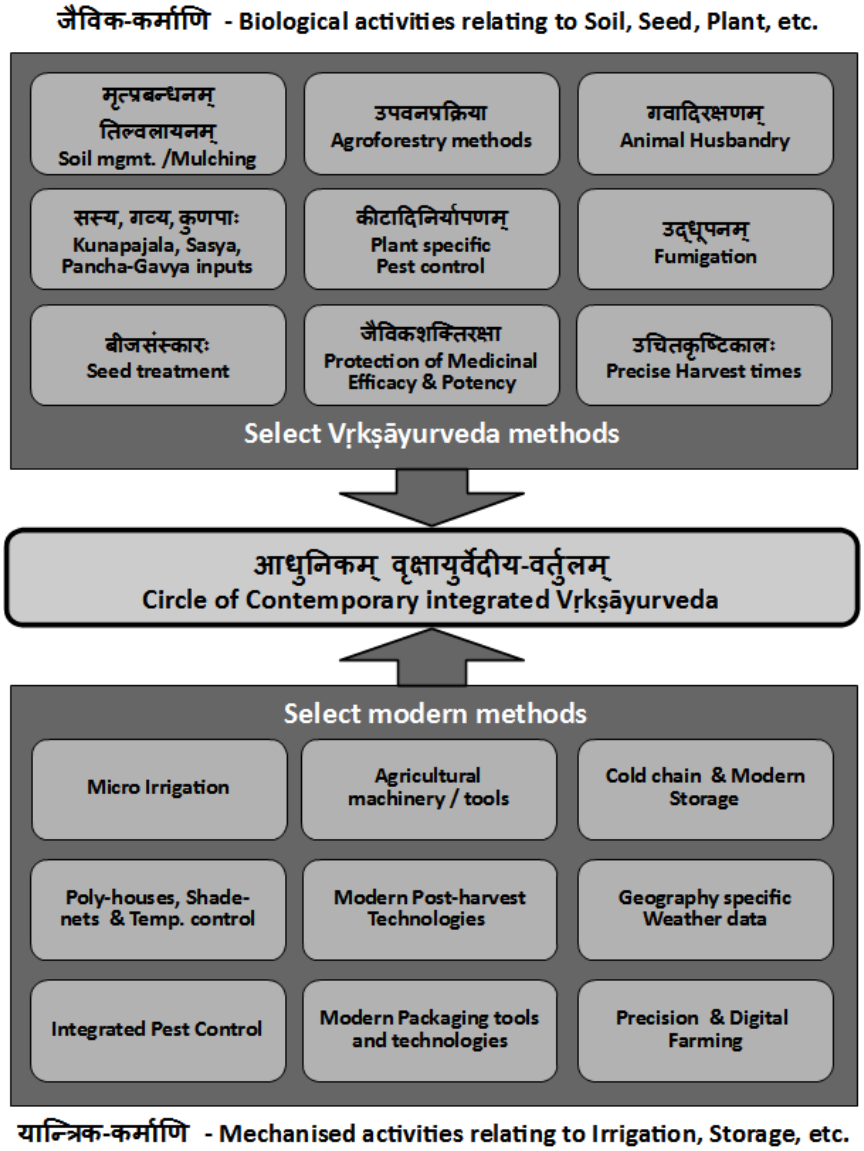

Figure No. 7.4 Integrated *Vṛkṣāyurveda* and modern methods

Conclusion

Worldwide trade of Medicinal and herbal products accounts for USD 120 billion (INR 883548,00,00,000 or 8.9 lakh crores approximately). Out of this India's share is only about USD 786.30 million (INR 5789,44,82,700 or 5790 crores). India's market share currently stands less than 1% of the world trade of herbs and herbal products. It is necessary to our market share in absolute terms and in value terms multi-fold in the next 5 -10 years. With respect to the low market share of India in the world trade of herbal products, the following key reasons were given by the Minister.

'(Parts of reply)

- *Inadequate Agricultural practices.*
- *Inadequate Quality Control procedure.*
- *Lack of large scale Organic Cultivation.*
- *Lack of Processing and R&D.*
- *Lack of Standardization in Products, Processes and Services.*
- *Lack of regulatory framework in trade of Medicinal Plants.*

The export of herbs and value-added extracts of medicinal herbs are gradually increasing over the years. India exported USD 330.18 Million worth of Herbs during 2017-18 with a growth rate of 14.22% over the previous year. Also, the export of value-added extracts of medicinal herbs / herbal products during 2017-18 stood at USD 456.12 Million recording a growth rate of 12.23% over the previous year'.

Majority of the medicinal plants of Ayurveda and Siddha are high flowering plants, out of which 33% are trees, 32% herbs, 20% shrubs, 12% climbers /creepers and 3% rhizomes /grasses. Due to the increased demand

across the world for herbal medicines, plant based drugs, nutraceuticals, etc. there are increased cultivation of many of the Medicinal plants across India.

With the increase in demand from the generic Ayurvedic supplements and personal-care products to specific medicinal products across the world, many of native wild species of medicinal plants are being brought under systematic cultivation. Currently about 100 traditional Ayurveda medicinal plants are being cultivated. However, for many of the wild species of Ayurveda medicinal plants cultivation protocols and methods are not available. In addition, the supply chains right from planting materials to cultivation to harvest to storage have not been established.

In the coming years, more number of wild medicinal plants are expected to be cultivated, more so with the WHO and Ministry of AYUSH standardization of Ayurveda across the globe. All these shall have direct impact on the cultivation of medicinal plants and the need for capacity building with respect to package of practices for MAP cultivation including agricultural protocols, nurseries and Quality planting materials.

In this scenario, the time tested methods of *Vṛkṣāyurveda* from various texts and also the ITK methods followed in the Tribal /rural agricultural practices should be researched in detail to arrive at solutions for the entire supply chain for 250+ medicinal herbs of Ayurveda, Siddha and Unani medicines.

Vṛkṣāyurveda is organic, traditional, cost-effective, indigenous, sustainable, less water intensive agricultural system of India and many of the ITK (Indigenous technical knowledge) practices in agriculture have their roots in *Vṛkṣāyurveda* and thus it is very easy to practice /implement.

Particularly in recent times of drastic climate change due to global warming, it is essential to switch to alternative methods of agriculture which are suitable to Indian geographical system. *Vṛkṣāyurveda* methods fit the bill as alternative from the contemporary water intensive chemical agricultural practices. In addition, *Vṛkṣāyurveda* can also meet the necessary agricultural yields while protecting nutritional needs of the country.

Cultivation of MAP (Medicinal and aromatic plants) is not only essential to meet the primary healthcare needs of the country, but also ensure economic sustainability of farmers. *Vṛkṣāyurveda* offers knowledge and several methods for the cultivation of MAP and also many Agroforestry designs.

Medicinal plants can easily be cultivated in agroforests and large poly-culture gardens. *Vṛkṣāyurveda* provides many agroforestry /garden designs as given in chapter 7, which can be effectively used for cultivation of medicinal plants along with vegetable crops. This shall ensure primary healthcare security along with food security.

Agroforests, through diverse plants help maintain plant biodiversity and as a result this helps the maintenance of biological activeness of the soil. Diverse plants in agroforestry systems release of plenty of chemicals and communicate with other plants and this helps all plants in the vicinity to develop resistance with respect to pest attacks and plant diseases. Recommendation of the crops that can be used depending on the land types and altitude, are given in chapter 7.

Vṛkṣāyurveda provides a lot of cultivation methods and cost-effective inputs from seed selection, seed treatment and plant nutrition and plant protection. Many of these methods and input substances are also specific to plant types. Therefore, these need to be studied in detail to arrive at various combinations of packages of botanical and bio-pesticides.

Further to the changes in Contract farming act 2018 in India (Agricultural Produce and Livestock Contract Farming and Services (Promotion and Facilitation) Act, 2018, Government of India) Medicinal plants can be cultivated much easier as contract farming crops across the country

The NMPB (National Medicinal Plants Board) has incentive structures and financial aids to promote and increase the cultivation of Medicinal plants across India. The number of plants for which the incentives are given should increased to including wild species of Ayurvedic medicinal plants.

Capacity building measures with respect to agricultural protocols, seed banks, medicinal plant nurseries, soil testing, agroforestry packages, training, cultivation support and inspection, should be done jointly with Agricultural universities, Contract farming companies and farmer cooperatives.

The current MPCA (Medicinal plant conservation areas) gardens in India need to be enhanced with *Vṛkṣāyurveda* based cultivation and conservation methods.

Government of India's electronic portals and mobile applications such as Vikaspedia.in, e-Nam and e-Charak apps can be further strengthened to

include package of practices and protocols based on *Vṛkṣāyurveda* at every step of medicinal plant cultivation, certification and storage.

Scope for further research and *Vṛkṣāyurveda* based MAP cultivation

Vṛkṣāyurveda being an application oriented scientific discipline, it offers a wide range of Ecologically supportive agroforestry practices and can provide solutions to many of the contemporary issues with respect to medicinal plant protection, including ex-situ cultivation of various herbs as given below.

'In-situ' study and 'Ex-situ' cultivation

Agricultural universities and research institutes can take up a program to study, plan, guide and oversee in-situ conservation and study of medicinal plants and also replication that in ex-situ cultivation for medicinal plants. In addition, model & community medicinal gardens can be created in each district with suitable MAPs according to the geography, water and soil conditions.

Study of 'In-situ' conditions of MAP clusters:

Study of the complete lifecycle & growth of 250 plants in their natural habitat as well as arid conditions. In addition, capturing the following data:

1. Rainfall information: 5-10 years
2. Soil conditions: pH, moisture, space between plants, water table
3. Environmental factors: Mean Sun-light, temperature, relative humidity, etc.
4. Establishing the base-line standards for the amount of active ingredients and other plant Phytochemicals present in the plants (in-situ) in their natural habitat and arid conditions

Replicate in Ex-situ cultivation in MPCA (Medicinal plant conservation areas) and community medicinal agroforests:

1. Establishment of Agroforestry models and plant recommendations for mimicking the environmental factors and all relevant growing conditions such as Soil humus, pH values, ground water tables, etc., in short the 'in-situ' conditions of the wild - natural growing areas of top non-cultivated herbs to replicate the habitat in community medicinal plant gardens

2. Testing with drought stress, heat stress, sun light stress, etc. and measuring both yield data and the active ingredients - through which establishing the baseline medicinal efficacy data for further references and refinement

3. Using *Vṛkṣāyurveda* methods to replicate the soil conditions and seed management, propagation across all medicinal plant conservation areas (MPCA) jointly with SMPB (state medicinal plants boards

4. Medicinal plants database of minimum 250 herbs and the most suitable growing conditions (cultivation protocols /package of practices) across various types of lands such as botanical gardens, parks, semi-arid lands, etc.

5. Establishment of nursery by collecting seeds and saplings from the native growing areas of non-cultivated medicinal plants - both critical and endangered ones and re-establishing them and reviving the medicinal plant wealth jointly with Forest department personnel, agriculturalists and Herbal medical practitioners.

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Appendix 1 Coursework and Credits certificate

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UH/Exams/Ph.D./CW/2021 **Date: 05.03.2021**

TO WHOMSOEVER IT IS CONCERNED

This is to certify that Mr. C G KRISHNAMURTHI (14HSPH02) was enrolled for Ph.D. Sanskrit Studies in the academic year 2014-15 and has completed the following coursework as per the requirement of UGC 2009 Regulations:

S.No.	Course Code	Course Name	Credits
1	SK801	Natural Language Processing	4
2	SK711	Indian Grammatical Theories	4
3	SK702	Padartha Vijnanam	4
4	SK803	Vrikshayurveda	4
5	HS830	Dissertation Related Readings	4

This certificate is issued on his request.

Deputy Registrar
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(शैक्षिक एवं परीक्षा)
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हैदराबाद विश्वविद्यालय
University of Hyderabad
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Appendix - 2 Certificates of Paper presentations

National Seminar on

"Sustainable Development Goals: Building Future India

March 26-28, 2019

ICSSR-SRC

Certificate

This is to certify that Dr./Ms./Mr. ..... C. Sri Kashmamuthi .....

has ~~participated~~/presented a paper titled ... Medical Plants Cultivation for diversity Conservation, Sustainability and Farmers Economic Sustainability .....

in the three day National Seminar on "Sustainable Development Goals and Building Future India"

organized (in collaboration with ICSSR- SRC, Hyderabad) by the Centre for the Study of Social Exclusion and Inclusive Policy (CSSEIP), School of Social Sciences, University of Hyderabad.

Prof. K. RAJA MOHAN RAO
HEAD, CSSEIP &
Seminar Coordinator

XIV AGRICULTURAL SCIENCE CONGRESS

Innovations for Agricultural Transformation

New Delhi, February 20-23, 2019

CERTIFICATE

Dr./Ms./MR. C.G. Krishnamurthi, Sanskrit Studies Dept., University of Hyderabad

has participated / presented poster in the XIV Agricultural Science Congress on 'Innovations for Agricultural Transformation',

held at National Agricultural Science Complex, New Delhi during 20-23rd February, 2019.

Presented a paper titled "Vrikshayurveda based cultivation of Medicinal and Aromatic plants in Agroforestry"

AKSingh

(AK Singh)
Organizing Secretary

RB Singh

(RB Singh)
Chairman
Scientific Programme Committee

Sri Jayendra Saraswathi Ayurveda College and Hospital

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We are grateful to

C.G. KRISHNA MURTHY

for having graced the occasion and enlightened our students by delivering a lecture on

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Certificate of Participation

This is to certify that

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has participated in the 16th World Sanskrit Conference held at
Renaissance Hotel, Bangkok, Thailand
from 28 June – 2 July, 2015, and has presented a paper entitled

प्रकरणस्य तात्पर्यावधारकत्वम्

in the Section

of the Conference.

Date: 2 July, 2015
Place: Bangkok

Assoc. Prof. Dr. Samniang Leurmsai
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Appendix - 3 Plagiarism check report

Critical study of *"Vṛkṣāyurveda"* texts for the cultivation of Medicinal and Aromatic Plants (MAP)

by

C.G Krishnamurthi
14HSPH02

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