Annals of Library and Information Studies
Vol. 72, December 2025, pp. 406-416
DOI: 10.56042/alis.v72i4.25672

Digitization of Indian Traditional Agricultural Practices in the Traditional Knowledge Digital Library – Towards Sustainability Science

Viswajanani J Sattigeri[a], Baleshwar[b], Anil Kumar[c], Vijayalakshmi Asthana[d] and Alpana Jain[e]
[a] Head, [b]Sr. Principal Scientist, [c]Principal Scientist, [d]Sr. Principal Scientist, [e]Principal Technical Officer
CSIR-Traditional Knowledge Digital Library (CSIR-TKDL) Unit, 14, Satsang Vihar Marg, New Delhi -110067, India
Email: viswajanani.sattigeri@csir.res.in, baleshwar.1997@csir.res.in, a.kumar@csir.res.in, viji.asthana@csir.res.in, alpana.jain@csir.res.in

Received: 04 March 2025; Accepted: 29 April 2025

Documentation of traditional knowledge (TK) has been given due importance internationally in the context of preservation and protection of one's rights. Global discussions also focus on integrating multiple knowledge systems for nurturing and stimulating innovations in the context of sustainable use and conservation of natural resources. The article provides a glimpse of the efforts being pursued by the Council of Scientific and Industrial Research (CSIR), India for enhancing the scope of the Traditional Knowledge Digital Library (TKDL) by way of including India's traditional agriculture information in the database. The vital factors for TK documentation include global initiatives on TK, information on traditional agriculture, patenting trends and innovation areas, data structure and ontology, among others. The article also highlights the synergy that can be drawn by bringing together TK, digital frameworks and sustainability science to address global challenges. Digital databases such as the TKDL can serve as important instruments towards the pursuit of sustainability science.

Introduction

Traditions and culture that shaped human evolution also defined the use of natural resources for growth and development, with due respect to the ecology and environment around. Practices based on keen observational skills, experimentations based on trial and error, and logical reasoning paved way for the ancient science based approaches. These approaches are often considered to operate in harmony with nature, and thereby ensure sustainable use and conservation of natural resources. This traditional knowledge (TK) serves as a continuing 'sustainable science' having traversed thousands of years and several human generations, still in use by society, and livelihood means to many communities. With the advent of modern science and technology (S&T) based industrial revolutions, growing human population and eroding natural resources, the need for 'sustainability science', is being strongly felt. At the same time, the TK systems have been looked down upon and are on the verge of extinction in several domains. This calls for due action for preserving knowledge systems that have sustained natural resources.

Sustainability science, envisioned as an integrative science, integrates knowledge, experimental action, adaptive management and social learning. It is also projected as a new faculty of science that is "committed to bridging barriers that separate traditional modes of inquiry", therein considering the plurality of knowledge systems with no distinction to regional origins[1,2]. In the context of achieving the United Nation's (UN) Sustainable Development Goals (SDG) 2030, bringing together the plurality of knowledge systems, i.e., the knowledge that has sustained time and resources, and the contemporary knowledge focused at global competitiveness, is critical. This is especially important considering the current challenges that impact life and sustainability, and therein growth and development.

Globally, several initiatives are being pursued to recognize the diverse regional and local knowledge systems, validate and integrate them appropriately in contemporary practices for the benefit of mankind and the planet. In this context, the indigenous knowledge systems though prevalent across nations, are not recorded or documented properly to serve as a strong basis for utilization and drawing benefits at scale. The UN bodies such as Food and Agriculture Organization (FAO), World Intellectual Property Organization (WIPO), Convention on Biological Diversity (CBD), and the G20 forum, among others, have been laying large emphasis on an inclusive approach involving

indigenous and local communities (ILCs). On this front, the agencies have also recommended the importance of documenting the knowledge systems.

The TK systems, that exist in codified and oral forms, are in use globally, serving societal needs in various forms and extents. However, with time, not only has the knowledge depleted but also languages and people associated with it. Documentation of such knowledge systems is therefore important from aspects of preservation, protection and promotion. India has been a frontrunner on initiatives related to TK and its promotion, in the context of both national and international priorities and commitments. The Traditional Knowledge Digital Library (TKDL)[3] from India that has been documenting Indian TK in the domain of traditional medicine and health systems is one such tool that has been serving the critical role of preserving and protecting Indian TK.

Digital tools are important, especially in the context of bringing together TK systems and advanced technologies. TK, digital technologies and sustainability science are increasingly intersecting in a way that is envisioned to offer powerful solutions for sustainable development by addressing and managing human needs.

This article describes some important international initiatives on sustainable agriculture and biological resources in the context of traditional indigenous knowledge systems and the importance given to documenting the TK systems. Further, the article provides a glimpse on efforts initiated by the CSIR, India for bringing out the usefulness of Indian Knowledge Systems (IKS) in agriculture through the digital library, the TKDL. The prior-art database is conceived as a robust information system of useful TK to drive sustainability science.

Objectives of the study

- To explore in brief international initiatives promoting TK systems, particularly related to agriculture and allied areas;
- To examine in brief the available literature, both texts and oral TK, related to traditional agriculture of India;
- To briefly understand the patenting trends in agriculture and allied areas and the related patent classification;
- To arrive at a structural framework of traditional agriculture of India for documenting the information as per the TKDL format; and
- To showcase the TKDL as a digital platform containing TK information can serve as a valuable instrument for sustainability science.

Scope and limitations of the study

The article addressing the aforesaid objectives is limited in its narrative to the major international initiatives from UN bodies such as FAO, CBD and WIPO, and the G20 forum in the context of exploring expansion of the TKDL scope by documenting traditional Indian agriculture in the database. The authors clarify that the efforts worldwide are larger than what is being described in this article, which can be the subject matter of future reviews on the matter.

International initiatives promoting traditional knowledge systems on agriculture and/or genetic resources

The FAO has been stressing the need for bringing together traditional and contemporary knowledge systems, recognizing the high importance of ILCs in preserving biodiversity, and the need to document the TK systems for enabling global welfare. The 'Globally Important Agricultural Heritage Systems (GIAHS)' are heritage systems (89 systems in 28 countries so far) that embody evolving and resilient techniques and practices that connect traditions and culture, landscapes, and agro biodiversity, which are sustainably managed by the knowledge holders[4]. The digital platforms namely, Technologies and Practices for Small Agricultural Producers (TECA)[5], Tropical Agriculture Platform (TAP, TAPipedia)[6] and FAO Biotechnology Forum[7], are envisaged to benefit farmers globally through information on successful agricultural technologies and interventions from across the world. The FAO is thus focused at integrating the plurality of knowledge systems, promoting 'transdisciplinary, transcultural and co-constructed knowledge', and linking cooperation between the researchers and ILCs, including farmers[8].

The CBD, with focus on conservation and sustainable use of biodiversity, advocates fairness and equity in access and benefit sharing from the use of GR and associated TK (GRATK). Specifically, Article 8(j) of the CBD is for the recognition of the rights of the ILCs. The CBD strongly recommends a framework of prior informed consent and benefit sharing on the utilization of GR and GRATK. Further, people's and community registries of biodiversity including GRATK are recommended. The 'Traditional Knowledge Information Portal' (TKIP) is to spread awareness and

promote information on TK, innovations and practices of the ILCs[9].

The WIPO through the Intergovernmental Committee on IP and GR, TK and Folklore (IGC) has been focusing on creating a legal framework since over two decades and thereby to provide protection from misappropriation and biopiracy[10]. The recent WIPO Treaty on IPR, GR and GRATK aims at enhancing the quality of patent grant system, and that non-novel inventions related to GR and GRATK are not granted patent rights. The Treaty mandates disclosure of source of origin of GR and GRATK, while also recommending establishment of suitable information systems for the purpose[11].

Challenges that impact global economy such as sustainable development, climate change, financial stability, international cooperation, are often the subject matters of discussion and consultation at the G20 forum. Some important recommendations of the G20 include:

- The G20 New Delhi Leaders' Declaration, New Delhi, India: To protect one's heritage, including associated IP, with due attention to its misuse, overexploitation and misappropriation and its impact on the sustainability and livelihoods of the knowledge holders and communities[12].
- Brazilian G20 Presidency's global initiative on bioeconomy: Focus on sustainable use of biodiversity, agricultural practices, food and feed, bioenergy, among others. For restorative bioeconomy, concept of socio-biodiversity, reinforced by TK is vital[13,14].

Herein, India's policy on 'Biotechnology for Economy, Environment and Employment (BioE3)' is focused at promoting sustainability in diverse ecosystems utilizing valuable knowledge of local communities[15].

India and the Traditional Knowledge Digital Library (TKDL)

India is well recognized for its rich and diverse traditions and culture, often an identity of the local people and communities. The knowledge systems, available in both codified and oral forms, are revered and practiced even today by a large majority of the people in the country. While the traditional ways of continuing knowledge systems and its protection have been through teaching and practice by the younger generations, this scope assumed significant change and newer context amidst global competitiveness and associated intellectual property (IP) rights. TK from not only India but several other countries became a subject matter of misappropriation owing to IPR grants. In this very context, the TKDL took birth in 2001 to protect Indian TK from misappropriation and biopiracy and prevent wrongful grant of patents on the Indian heritage.

The TKDL serves to bridge the gap of accessibility, comprehension and interpretation of Indian TK by patent examiners, especially in view of the diversity of languages and formats in which the knowledge and practices are presented in texts covering the subject matters or orally. The objective was to ensure that patent examiners understand the prior-art information of Indian TK presented in the TKDL while examining patent applications during the grant procedure, and raise observations when appropriate. The digital framework of the TKDL facilitates ease of documentation with standard and uniform terminologies, which in turn helps in information retrieval relevant to the invention being claimed in a patent application. The data structure of the TKDL thus assumes greater significance, and this has been aptly met through the unique classification of TK information through the Traditional Knowledge Resource Classification (TKRC) codes that serve as the metadata of the database. The TKRC also draws conformity with the International Patent Classification (IPC) codes to assist patent examiners in their search procedures.

The TKDL focused at documenting the Indian Systems of Medicine (ISM) and health, viz., Ayurveda, Unani, Siddha, Sowa Rigpa and Yoga, with over 5.19 lakh formulations and practices transcribed, has been serving as a rich repository of Indian TK. The access to the database has been given to 17 patent offices around the world through Non-Disclosure Access Agreements. So far, through the evidences from the TKDL database about 375 positive outcomes on preventing misappropriation of Indian TK have been realized. These outcomes include patent applications being rejected, claims amended or the application withdrawn or abandoned by the applicant. The success with the ISMs gave a boost to the CSIR, aptly supported by the National IPR Policy 2016, to venture into other subject areas. One of the key areas chosen for expanding the scope of the TKDL has been Indian traditional agriculture and allied areas.

Documentation of traditional agricultural practices of India

India has been an agrarian nation since ancient times. The traditional agriculture covers diverse biodiversity, farming techniques, crop varieties,

including land races, post-harvest processing, storage, among others. This diverse heritage has been contributing to India's sustainable agriculture and food security, even in the context of wide spread modern contemporary practices. Thus, preservation and revitalization of these practices in the context of achieving the SDGs become important. The TK related to agriculture and allied areas are available both in codified as well as oral forms. Brief information on the sources of codified and oral TK on agriculture is given below:

A. Texts on traditional agricultural practices of India

Agriculture in India constitutes diverse practices and techniques. Traditional agriculture has had a harmonious blend with animal husbandry providing farmers a sustainable livelihood. Various ancient texts

S. No.	Text-Author-Language	Information
(i)	**Gavyayurveda (Cow) by Sahadeva**[16,17] Sanskrit	Comprehensive approach to managing health and productivity of cows, covers preventive health care, herbal treatments, milk production, work, and sustaining agricultural economy
(ii)	**Mrig-Ayurveda (Animals) by Shalihotra**[16,17] (c. 2350 BCE) Sanskrit	Focus on animal welfare, management, treatment, and surgery. It is based on Ayurveda and uses medicinal plants to treat diseases in domesticated animals
(iii)	**Asvayurveda (Horse) by Shalihotra**[16,18] (c. 2350 BCE) Sanskrit	Text on history of veterinary science in India, focusing on the holistic care and management of horses with emphasis on health care, training, nutrition, and disease prevention and the integral role of horses in ancient Indian agriculture, economy, and military
(iv)	**Hastyayurveda (Elephants) by Palakayya Muni**[19] (c. 1000 BCE) Sanskrit	Focus on health and management of elephants, assistance in farming and labour-related tasks
(v)	**Krishi-Parashara by Parashara**[20] (c. 400 BCE) Sanskrit	The oldest text book on Indian agricultural knowledge, with details, including names, parts and measurement of agricultural implements, such as plough, and the quality and strength of implements, methods for predicting rainfall round the year, cattle management, seed preservation, among others
(vi)	**Mahabhashya by Patañjali**[21] (c. 200 BCE) Sanskrit	Dictionary of *materia medica* in six skandhas (chapters), each corresponding to different Rasa, covering fields of medicine, astronomy and mathematics, encyclopaedic glossaries and technical dictionaries
(vii)	**Arthasastra by Kautilya**[22] (c. 300 AD) Sanskrit	Comprehensive framework for the promotion and management of agriculture, state's role in supporting farmers, managing resources such as water, fair taxation, and promoting trade, etc.
(viii)	**Shukraniti by Shukracharya**[23] (c. 400 AD) Sanskrit	Provides guidance on politics, economics, ethics, statecraft, social, and political aspects. Also mentioned are the characteristics of horses, elephants, cow and other animals, besides ways of managing the storage of grains
(ix)	**Brihat Samhita by Varahamihira**[24] (c. 600 AD) Sanskrit	Information on astronomy, geography, physiognomy, meteorology, portents, agriculture, botany, economics, zoology, physiology, architecture, sculpture, psychology, medicine, gemology, prosody, calendar, stellar lore, figures of speech, etc. The information on seed treatment for germination and protection from pests and insects is particularly relevant to agriculture and farming
(x)	**Kashyapiyakrishisukti by Kashyapa**[25] (c. 800 AD) Sanskrit	Instructions to the farmers on various aspects of farming such as irrigated rice production, soil properties, cultivation of legumes on uplands, cultivating the vegetables, fruits, spice crops, ornamentals, trees, laying out the gardens, marketing of produce, mining and even preparation of reservoirs for irrigation purpose
(xi)	**Vrikshayurveda by Surapala**[26] (c. 1000 AD) Sanskrit	Primary text on the science of plant life, mainly dealing with healthy growth and productivity of approximately 170 species of economically useful plants. Various chapters emphasise glorification of tree plantation, merits and demerits, classification, protection, nourishment, horticultural wonders, pleasure gardens, procurement, preservation, and treatments of seeds and planting materials

(*Contd*.)

S. No	Text-Author-Language	Information — (*Contd.*)
(xii)	**Lokopakara by Chavundaraya II**[27] (c. 1115-1042 AD) Old Kannada	Describes topics such as astrology, portents, vastu (architecture), water and associated divinity, vrikshayurveda, perfumery, cookery, veterinary medicine, tree species, termitoria, coloured rocks, fauna, grasses, bioindicators for detecting the ground water, insect pest control using fermented preparation based on cow urine and anti-insect herbals; and several variants of fermented liquid manure 'Kunapajala'
(xiii)	**Manasollasa (Abhilashitartha Chintamani) by Kalyani Chalukya king Someshvara III**[28] (c. 1200 AD) Sanskrit	Encyclopaedia covering ethics, astrology, astronomy, architecture, painting, horticulture, food, perfumes, veterinary medicine, economics, politics, governance, rhetoric, sports, music and others
(xiv)	**Shrangdharapaddhti by Shrangdhara**[29] (c. 1300 AD) Sanskrit	Role of agriculture in growing high-quality medicinal herbs, natural farming methods, plant potency and health benefits
(xv)	**Upavana Vinoda by Sarangadhara**[30] (c. 1300 AD) Sanskrit	Anthology on glory of trees, soil selection, digging wells, classification of plants, sowing of seeds, planting and watering, methods of protecting and nourishing the plants, construction of a garden house, kunapajala preparation, treatment of plants in diseases, botanical marvels, among others
(xvi)	**Krishi Gita by Parasurama**[31] (c. 1500 AD) Malayalam	Treatise on indigenous farming practices used for cultivating the crops in coastal regions of Kerala covering management of soil by ploughing, manuring, escaping water retention and iron toxicity, optimum seed requirement, planting time, spacing between plants and rows. Mentions a large number of rice (124) varieties and other crops such as areca nut, amaranth, ash gourd, banana, chickpea, beans, etc.
(xvii)	**Vishvavallabha by Sri Chakrapani Mishra**[32] (c. 1577 AD) Sanskrit	Provides useful insights on divining groundwater, methods to harvest rain water, construction of water reservoirs, planting trees inside a fort, and cultivating horticultural crops besides managing pests and disease, etc.
(xviii)	**Nuskha Dar Fanni-Falahat by Dara Shikoh**[33] (c. 1650 AD) Persian	Describes the art of cultivating of approximately 100 species of economic plants such as fruits, vegetables, cereals, legumes, aromatic plants, ornamentals, roadside and timber trees, orchard development. It provides first mention of Nitre as a fertilizer to sprinkle on vines and of Baqla for its qualities of manure
(xix)	**Shivatattvaratnakara by Basavaraja**[34] (c. 1700 AD) Sanskrit	Text covering a wide range of topics including music, dance, cookery, and various aspects of Hindu philosophy, including mention of the concept of plant mutagenesis: *druma-vichitrikaranam; druma* = tree and *vicitrīkaraṇa* = to make (it) appear extraordinary
(xx)	**Krishishashanam by Sri Dashrath Shastri**[35] (c. 1920 AD) Sanskrit and Hindi	Provides useful information on soil characteristics, ploughing with bullocks, animal health, seed health, methods of sowing of various crops, predicting the rainfall, harvesting and farm implements

are available on the subject matter in different regional languages. The techniques documented in various texts cover the gamut of agricultural practices such as cropping systems including mixed cropping, crop-rotation and inter-cropping, animal-plant farming, poultry-animal husbandry, fish-poultry farming, agro-forestry, organic farming, horticulture, implements, tools and devices, irrigation systems, selection and preservation of seeds and germplasms, methods of weed control, protection of trees, storage, preparation of recipes, perfumes, animal treatments and others. Brief information on some classical texts related to traditional agriculture from India are given above:

B. Indigenous Technical Knowledge in Agriculture of India (ITK)

Traditionally, agriculture has been practised by the farmers, local people and communities. The knowledge and practices are often oral and not documented. Several traditional practices are still followed by the farmers and their communities, which continue to be handed down to the younger generations by word of mouth.

Several ethnoagri surveys have facilitated collection and documentation of knowledge and practices of the local farmers, people and communities. Of particular importance is that of the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture, Govt. of India. The ICAR launched a National Mission Mode project entitled, 'National Agricultural Technology Project (NATP)' in 2000 to collect and document indigenous technical knowledge (ITK) in agriculture practised in the country. Seven publications documenting the ITKs on several topics have been brought out. These include agronomy, animal husbandry, veterinary, fishery, agro-biodiversity, natural yarns, ethno-botany, ethnic food, dyes and

weaves, food product development, garbage disposal and management, waste water management, low cost housing materials, weather forecasting, among others. Some ITKs have been validated. The details of the texts are as follows:

(i). **Inventory of Indigenous Technical Knowledge in Agriculture - Document 1**[36]**:** Covers information on well classified 263 TK systems

(ii). **Inventory of Indigenous Technical Knowledge in Agriculture - Document 2.1**[37]**:** A total 562 practices are described into different topics.

(iii). **Inventory of Indigenous Technical Knowledge in Agriculture - Document 2.2**[38]**:** A total 846 practices are documented into various topics.

(iv). **Validation of Indigenous Technical Knowledge in Agriculture - Document 3**[39]**:** Describes the experiments carried out by ICAR institutes and State Agricultural and Animal Science Universities to validate ITKs.

(v). **Cross-sectoral Validation of Indigenous Technical Knowledge in Agriculture - Document 4**[40]**:** Provides information on scientific insights on cross sectoral validation of 38 ITKs.

(vi). **Geographical Indications (GI) of Plant Species in ITKs in Agriculture - Document 5**[41]**:** Documents 228 plant species for their GIs with information on local names, habitats, active constituents, therapeutic effects, etc.

(vii). **Traditional Knowledge in Agriculture**[42]**:** Provides useful insights on selected 38 ITKs covering six thematic areas viz, rain water management, soil and water conservation, pest and disease management, farm implements, horticultural crops, and fishery and animal husbandry.

In today's context, protection and promotion of TK are important. Therefore, validation of TK assumes greater significance in establishing the value of TK and promote TK-inspired innovations. For example, *Cleistanthus collinus* (Roxb.) Benth. ex Hook.f, also known as *toxic gooseberry*, *parso* or *persu*, is used for control of gall fly (*Pachydiplosis oryzae*) in rice by farmers in Jharkhand[40]. This age-old practice of spreading *parso* leaves, a natural and environment friendly resource, at initial stages is helpful in controlling 70-80% infestation. The experimental validation of the ITK by Birsa Agricultural University, Ranchi at Central Research Farm, Bidhan Chandra Krishi Vishvavidyalaya, Nadia revealed similar effects to that of carbofuran, the conventional treatment. The practice thus stood scientifically validated for its effectiveness even in current times.

Patenting trends in agriculture and food sectors – Patent Informatics, Misappropriation, and TK-inspired Innovations

India, by default and strategy, has been balancing innovation in the agricultural sector, through ensuring affordability and accessibility of agrifood technologies and innovations while attentive to the contexts of protecting innovations through IPR provisions. This balance shall contribute to availing the benefits of innovations, while also contributing to sustainable agriculture and food security in the country.

To begin with, it was important to have an overview of the patenting trends in agriculture and food sectors. The IPCs related to agriculture include A01- Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing and the sub-classes, A01B to A01P, mentioned therein[43]. The IPCs are important in the context of the data structure of the TKDL and deriving the TKRCs on traditional agricultural practices. This exercise is vital for entering subject data in the TKDL database towards enabling ease of search and information retrieval by patent examiners.

Patent Informatics of the agrifood sector allows one to understand the innovation in these sectors that help in sustainable practices, addressing the SDGs related to food production, farming, consumption and waste management, and thereby socio-economic development. According to the WIPO Patent Landscape Report of 2024 on Agrifood, covering a 20 years period from 2004 to 2023, >3.5M patent families have been published covering the agri-food sectors, with AgriTech constituting 60% and FoodTech constituting 40% of total patent counts[44]. The main technology areas of the agrifood sector include soil and fertilizer management, non-pesticide and disease management, alternative nutrient sources for human food, predictive models and autonomous devices in precision agriculture.

Of importance are the patenting trends in pest and disease management, which also encompasses a range of innovations designed to control crop pests without relying on harmful chemical pesticides. The patenting trends in soil and fertilizer management indicate that this segment is focused at novel inventions aimed at enhancing soil health and fertility, which are critical for ecosystem biodiversity, water management, sustainable agriculture and climate resilience. Plant

based alternatives for meat, seafood, egg and dairy products, made from a variety of plant sources such as soy, wheat, beans, duckweed and algae, are at the forefront of technological advancements in the food industry.

The ICAR examined global and domestic patent trends during the period covering 1990 to 2022 in the agriculture sector, and covering 37 countries[45]. The study had a major focus on countries like India, China, and North America, that lead patenting activities in the area of agriculture. During this period ~2.18M patent applications were filed in the agriculture and allied sectors. Following China and the USA, India saw an increase in agricultural patents in areas of crop improvement, agricultural machinery and agrochemicals, among others. It is important to note that in India, plant variety protection through the Protection of Plant Varieties and Farmers' Rights Act (PPVFRA), 2001 is a unique alternate legislation, that also allows for recognition of traditional farmers' varieties.

A preliminary examination of patent applications filed in the area of agriculture based on herbal components revealed that there is significant interest in herbal compositions. The use of such compositions is very common in the form of biocides – herbicides and pesticides to treat plants and agriculture produce. Other applications lie in nutrients for plants as well as in domesticated animals/ fish; as organic fertilizers; improving soil health, inhibiting weeds and so on. Examples of patent applications include: (i) use of neem oil mixed with carbonates/ bicarbonates of sodium or potassium to control red palm weevil; (ii) use of cow or buffalo dung and urine along with other plant materials including banana stem/leaf to improve soil fertility and as nutrients for plants; (iii) anti-viral medicaments for animals using extract of *Nerium oleander* L. or its combinations; (iii) plant extract compositions to stimulate defence against viruses, etc.

However, misappropriation of Indian TK related to agriculture is a prime concern. The wrongful grant of patents on non-patentable knowledge, especially that related to traditional and indigenous knowledge, result in loss of ownership rights to the knowledge and systems that have been part of one's inheritance. The cases of misappropriation and biopiracy have been a great concern to nations such as India, Philippines, Africa, among others. Litigation was the only available route to fight for revocation of these erroneous grant of patents to known subject matters. Some examples of wrongful patent grants related to traditional Indian agriculture include Neem and its fungicidal properties[3,46] by US Corporation W.R. Grace Company and US Department of Agriculture, Basmati rice grains and lines[3,47] by RiceTec. Inc., USA, Kilta, a traditional product for collecting agricultural produce[48] etc.

Herein, it is also important to focus on the continued relevance of TK systems through TK-inspired innovations, wherein elements of novelty, and technical advancement over the already known TK subject matter duly justify the patent grants. Some examples include a patent bearing No. 409688 granted by the O/o CGPDTM, India for 'Veterinary Herbal Formulation of *Terminalia chebula* Retz'[49], the patent 9827284B2 granted by the USPTO on 'Methods for improving milk letting down in milch animals'[50], and the patent 8663623B2 on 'Herbal cattle feed supplement compositions for enhancing productivity and quality of milk'[51] granted by the USPTO.

Documentation of traditional agricultural practices of India and structural framework in the TKDL

As seen in preceding sections, the information on traditional agricultural practices of India is available both in the codified and oral forms, as with TK of other subject areas from the country. A preliminary review of the traditional agricultural practices of India indicates that diverse subject matters have been covered in the texts and also oral TK. These relate to many aspects of both the plant and animal species, including the aquatic life forms. Today, integrated farming systems form an integral part of the recent initiatives from India towards addressing sustainable agriculture, therewith aiming at agricultural diversification and reforms for enhancing rural development and livelihood of the farmers and local communities. Thus, the traditional agricultural practices have immense value even when considering integrated farm management systems.

Further, considering the rampant patenting activities, exemplary cases of misappropriation of Indian TK related to agriculture and TK inspired innovations, the prevention of loss of India's ownership rights to its own TK and promoting TK for welfare assume high importance. The TKDL has thus been envisioned as an important platform to capture the traditional agricultural practices of India and address the cause. The CSIR proposes to transcribe information from the classical and other texts

mentioned in Section 6 into the TKDL.

The task thereafter was to arrive at a feasible structural framework that can capture the traditional agri practices of the country in the TKDL in accordance with the laid out procedures and processes as with the ISMs. From a classification purpose, the IPC system would be of vital consideration for classification of data related to traditional agriculture, particularly Class A01 and the major sub-classes, A01B to A01P for mapping the TK systems.

Important texts such as Krishi-Parashara, Kashyapiyakrishisukti, Vrikshayurveda, Vishvava-llabha and Brhat Samhita were studied. The topics are diverse, ranging from cropping systems, mixed cropping, integrated farming such as plant-animal husbandry, poultry-animal husbandry, and fish-poultry farming, natural and organic farming, agro-forestry, agri implements, seed and germplasm preservation, irrigation systems, post-harvest techniques, to animal and plant health, among several others. A preliminary exercise indicated that the Indian TK related to agriculture could be well classified and in conformity to IPC classes. The structural format was then delineated to include the information under three important domains of Indian traditional agriculture namely crop husbandry, animal husbandry and fishery as classes in the TKDL database. Further, following extensive discussions with national experts on the matter, a structural framework (Fig. 1) has been arrived at that would capture the TK information on agriculture and allied areas under diverse sub-classes. The Classes and Sub-classes under the TKDL, given in Figure 1, largely cover the agriculture related topics mentioned in the traditional texts as well as the sub-classes mentioned under the IPCs.

In accordance with the structural format desired for digitization of traditional agricultural knowledge into the TKDL, groups and sub-groups based on the actual information will be arrived at. The TKRCs shall be created for providing the metadata, and concordance between the TKRCs and the IPCs shall be drawn, where feasible.

The structural format shall thereby enable a sound data ontology for referencing, cross-referencing and build-in relational links on Indian TK, offering therewith standard and uniform terminologies. The digitized data of India's traditional agriculture in the TKDL database will then be useful for patent pre-grant procedures, adoption of the ITK, and adaptation through value addition by further R&D and innovation.

TK digital platforms as a potential instrument for sustainability science – TKDL as a case in point

In the context of agriculture and sustainability, TK provides for a deep understanding of sustainable farming techniques, natural resource management, and resilience to changing ecosystems and environmental conditions, including climate change. The national and global initiatives such as that of the UN Bodies and G20 forum indicate the increasing recognition being given to TK systems as a vital source for addressing modern sustainability challenges, especially in the contexts of efficient use of natural resources and conserving biodiversity. Digital tools, in the context of sustainability science,

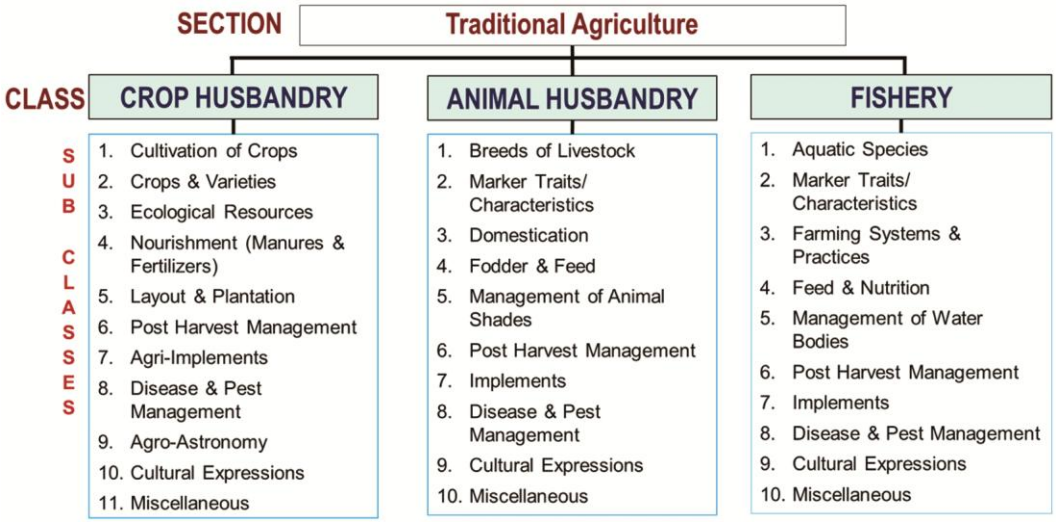

Fig. 1 — Structural framework for capturing information on traditional agriculture in the TKDL

provide for technological and data-driven frameworks that can be used for integrating and analysing vast amounts of information to support decision-making for sustainable development. A key component of the digital framework is the development of databases, registries and online platforms that document, store, and share TK, ensuring its preservation and protection, while facilitating utilization of TK in modern sustainability contexts.

As stated previously, sustainability science in the context of plurality of knowledge systems and interdisciplinarity, focuses on knowledge forms of various subject areas, and therein facilitates understanding the complex interactions between human and environmental systems. In the context of this inter-dependency and potential synergy between disciplines, sustainability science that seeks to incorporate local and indigenous knowledge to find context-specific solutions for sustainability challenges, will require digital frameworks as the foundational platforms. Herein, the TKDL can be visualised as an important platform that can showcase how the intersecting fields of traditional agriculture and digital frameworks can be an important facet for driving sustainability science.

The international initiatives, although touched in brief, highlight the need and importance of bringing together traditional and contemporary knowledge systems. The international initiatives also exhort the need to protect the rights of the nations and the knowledge holders, highlighting therewith the need for careful documentation and monitoring, preferably through digital information systems. The TKDL has been serving the purpose of the above, documentation and protection, in the context of Indian traditional medicine, and now poised to address the needs of traditional agriculture from the country.

Careful analysis of the patenting trends, understanding the key areas of IPR, along with analysis of the TK information from ancient texts related to the subject area, herein agriculture, do indicate the continued interest in nature based solutions and the TK systems. The patent informatics data and the patent classification codes help in arriving at a meaningful ontology and thereby the data structure that can help the current and future generations in better understanding and appreciation of the ancient knowledge systems. The structural data framework of the TKDL presented in the context of India's traditional agriculture highlights the vastness of disciplines and subjects that can be of great benefit to the modern sustainability science initiatives on agriculture and food.

The TKDL can help manage and analyse the traditional agriculture information, making it accessible to patent examiners for meeting its mandate on preventing misappropriation and biopiracy, and also to scientists and other stakeholders, including farmers for pursuing sustainable and nature-respecting practices. The digital database with TK information related to agriculture or other subject areas can thus serve as an important instrument for sustainability science in the respective domains.

Conclusion

The TKDL presents itself as an important documentation and data framework that combines TK, digital technologies and sustainability science for fostering inclusivity in approach and use of multiple knowledge systems for sustainability of lives, ecology and environment. The use of digital databases and technologies ensures that the ancient knowledge systems are preserved, and made accessible for judicious use, wherein native knowledge can be used as is or to inform modern sustainability practices for co-optation and integration. From the angles of protection, digital databases and registries such as the TKDL are important information systems that can thwart misappropriation and biopiracy, while also enabling its utilization. The structural ontology needs to be carefully drawn to capture all the required contents of the TK systems, with uniform and standard terminologies connecting TK and modern parlance, so the value of these TK systems can be easily understood and used. The TK databases can thus provide for creating a more holistic approach and strategy to attain sustainability science by integrating TK and modern knowledge systems for addressing global challenges such as biodiversity loss, resource depletion and climate change. In the times to come, initiatives such as the TKDL worldwide can provide a robust platform for knowledge sharing and fostering more meaningful innovations in sustainability practices based on both traditional wisdom and modern insights, and recognising the rights of the concerned knowledge holders.

Acknowledgements

The authors acknowledge the advice and support received from Dr. Mangala Rai, Dr. Trilochan Mohapatra, Dr. S.P.S. Beniwal, Dr. Satyabrata Maiti, Prof. Sunita T. Pandey, Dr. A.V. Balasubramanian, Dr. B. Subramaniam and Dr. T.K. Mukherjee during the

conceptualization of the work and drafting of the structural framework.

References

1 National Research Council (1999). Our Common Journey: A Transition Toward Sustainability. Washington, DC: The National Academies Press. https://doi.org/10.17226/9690.

2 National Research Council (2001). *The Science of Regional and Global Change: Putting Knowledge to Work.* Washington, DC: The National Academies Press. https://doi.org/10.17226/10048.

3 *Home (2025). Traditional Knowledge Digital Library (TKDL). Council of Scientific and Industrial Research (CSIR). https://www.tkdl.res.in/tkdl/langdefault/common/Home.asp?GL=Eng, Last accessed 04-03-2025.*

4 Home (2025). Globally Important Agricultural Heritage Systems. Food and Agriculture Organization of the United Nations. https://www.fao.org/giahs/en. Last accessed 02-03-2025.

5 TECA (2025). Technologies and Practices for Small Agricultural Producers. Food and Agriculture Organization of the United Nations. https://teca.apps.fao.org/en. Last accessed 02-03-2025.

6 TAPipedia (2025). The Tropical Agriculture Platform (TAP). Food and Agriculture Organization of the United Nations. https://www.fao.org/in-action/tropical-agriculture-platform/tapipedia/en. Last accessed 02-03-2025.

7 FAO Biotechnology Forum (2025). Research and Extension Systems. Food and Agriculture Organization of the United Nations. https://www.fao.org/research-extension-systems/portals/fao-biotechnology-forum/en. Last accessed 02-03-2025.

8 FAO and Alliance of Bioversity International and CIAT (2021). Indigenous Peoples' food systems: Insights on sustainability and resilience from the front line of climate change. Rome. https://doi.org/10.4060/cb5131en. Last accessed 02-03-2025.

9 Home (2023). Traditional Knowledge Information Portal. Convention on Biological Diversity. https://www.cbd.int/tk/about.shtml. Last accessed 02-03-2025.

10 Home (2025). Intergovernmental Committee (IGC). World Intellectual Property Organization. https://www.wipo.int/en/web/igc. Last accessed 02-03-2025.

11 Home (2024). WIPO Treaty on Intellectual Property, Genetic Resources and Associated Traditional Knowledge. World Intellectual Property Organization. WIPO Treaty on IP, GR and Associated TK. Last accessed 02-03-2025.

12 G20 New Delhi Leaders' Declaration (2023). Ministry of External Affair, Govt. of India. New Delhi, India. https://www.mea.gov.in/Images/CPV/G20-New-Delhi-Leaders-Declaration.pdf. Last accessed 02-03-2025.

13 The Global Bioeconomy (2024). Preliminary Stocktake of G20 Strategies and Practices: a contribution to the Brazilian G20 Presidency's Global Initiative on Bioeconomy. Nature Finance. https://www.naturefinance.net/wp-content/uploads/2024/05/ENG-TheGlobalBioeconomy_FINAL.pdf. Last accessed 02-03-2025.

14 G20 Initiative on Bioeconomy (2024). G20 High-Level Principle on Bioeconomy. World Bioeconomy Forum. https://wcbef.com/wp-content/uploads/2024/12/2024-09-11-high-level_principles_on_bioeconomy-final_version.pdf. Last accessed 02-03-2025.

15 India BioEconomy Report (IBER) (2024).BioE3 Policy (Biotechnology for Economy, Environment and Employment). Department of Biotechnology, New Delhi; https://bmi.dbtindia.gov.in/pdf/folder.pdf. Last accessed 02-03-2025.

16 Nair, S. (2021). The Indian Strategy of One Health Concept. HSOA Journal of Alternative, Complementary & Integrative Medicine 7: 183. DOI: 10.24966/ACIM-7562/100183.

17 Gandhi, M.S. (2022). Ayurveda-a living style. People For Animals. https://www.peopleforanimalsindia.org/articles/detals/232.

18 Bhati, H.S. (ed.) (2004). Asvayurveda by Shalihotra. Rajasthani Shodh Sansthan, Chopasni, Jodhpur. 144 pp.

19 Sharma, S.D., Apte, M.C. (eds.) (1894). Hastyāyurvedaḥ by Muni Pālakapya. Anandashrama Series, Pune.

20 Sadhale, N. (Tr.) (1999). Krishi-Parashara (Agriculture by Parashara). Agri-History Bulletin No. 2. Asian Agri-History Foundation, Secunderabad, India. 94 pp.

21 Dasgupta, S. (1991). The Mahabhasya of Patanjali. Indian Council of Philosophical Research (ICPR), India. 256 pp.

22 Shamasastry, R. (1961). Arthasastra by Kautilya (7th ed.). Mysore Printing and Publishing House, Mysore, India. 448 pp. (First edition published in 1915)

23 Parikh, M., Buch, V. (2023). Shukraniti by Shukracharya (vol. 1-2). Chowkhamba Vidya Bhawan, Varanasi.

24 Iyer, N.C., Jugnu, S.K. (2018). Brhat Samhita by Varahamihira (vol. 1-2). Parimal Publications, New Delhi.

25 Ayachit, S.M. (Tr.) (2002). Kashyapiyakrishisukti (A Treatise on Agriculture by Kashyapa). Agri-History Bulletin No. 4. Asian Agri-History Foundation, Secunderabad, India. 158 pp.

26 Sadhale, N. (Tr.) (1996). Surapala's Vrikshayurveda (The Science of Plant Life by Surapala). Agri-History Bulletin No. 1. Asian AgriHistory Foundation, Secunderabad, India. 104 pp.

27 Valmiki, S.A. (Tr.) (2006). Lokopakara (for the benefit of people by Chavundaraya II). Agri-History Bulletin No. 6. Munshiram Manoharlal Publishers Pvt. Ltd, New Delhi. 139 pp.

28 Bhalla, D.O. (ed.) (1938). Manasollasa by the Kalyani Chalukya king Someshvara III. Bhartiya Vidya Bhavan, New Delhi. 353 pp.

29 Peterson, P. (ed.) (2010). Sarngadhara Paddhati by Sarngadhara. Kessinger Publishing. 782 pp.

30 Sadhale, N. (Tr.) (2011). Upavana Vinoda (Woodland Garden for Enjoyment by Sarangadhara). Asian Agri-History Bulletin No. 8. Asian Agri-History Foundation, Secunderabad, India. 64 pp.

31 Kumar, B.M. (Tr.) (2008). Krishi Gita (Agricultural Verses by Parasurama). Asian Agri-History Bulletin No. 7. Asian Agri-History Foundation, Secunderabad, India. 120 pp.

32 Sadhale, N. (Tr.) (2004). Vishvavallabha (Dear to the World: the science of plant life by Sri Chakrapani Mishra). Agri-History Bulletin No. 5. Asian Agri-History Foundation, Secunderabad, India. 134 pp.

33 Akbar, R. (Tr.) (2000). Nuskha Dar Fanni-Falahat (The Art of Agriculture). Asian Agri-History Bulletin No. 3. Asian Agri-History Foundation, Secunderabad, India. 126 pp.

34 Rao, B.R., Shastriar, P.S. (1927). Shivatattvaratnakara by Basavaraja. B. M. Nath & Co., Vepery, Madras. 465 pp.

35 Rahudkar, W.B. (Tr.) (2011). Krishishasanam (Krishishastra by Dashrathashastri). Asian Agri-History Bulletin No. 8. Asian Agri-History Foundation, Secunderabad, India. 63 pp.

36 Das, P., Das, S.K., Arya, H.P.S., Reddy, G.S., Mishra, A.

(2002). Inventory of Indigenous Technical Knowledge in Agriculture - Document 1. Division of Agricultural Extension, ICAR, New Delhi. 423 pp.

37 Das, P., Das, S.K., Mishra, A., Arya, H.P.S., Bujarbarua, K.M., Singh 'Ratan', R.P., Verma, L.R. Reddy, G.S., Rani, M.G., Gupta, H.S., Kavia, Z.D., Ray, D.P. (2003). Inventory of Indigenous Technical Knowledge in Agriculture - Document 2(suppl. 1). Division of Agricultural Extension, ICAR, New Delhi. 192 pp.

38 Das, P., Das, S.K., Mishra, A., Arya, H.P.S., Singh, R.P., Reddy, G.S., Verma, L.R., Rani, M.G., Ray, D.P. (2003). Inventory of Indigenous Technical Knowledge in Agriculture - Document 2(suppl. 2). Division of Agricultural Extension, ICAR, New Delhi. 326 pp.

39 Das, P., Das, S.K., Mishra, A., Verma, L.R., Singh 'Ratan', R.P., Arya, H.P.S., Reddy, G.S., Rani, M.G., Gupta, H.S., Ray, D.P., Kavia, Z.D. (2004). Validation of Indigenous Technical Knowledge in Agriculture – Document 3. Division of Agricultural Extension, ICAR, New Delhi. 492 pp.

40 Das, P., Das, S.K., Mishra, A., Singh 'Ratan', R.P., Reddy, G.S., Arya, H.P.S., Rani, M.G., Verma, L.R., Ray, D.P. (2004). Cross-sectoral Validation of Indigenous Technical Knowledge in Agriculture – Document 4. Division of Agricultural Extension, ICAR, New Delhi. 225 pp.

41 Das, P., G.S., Rani, Das, S.K., Mishra, A., Singh 'Ratan', R.P., Reddy, G.S., Arya, H.P.S., Verma, L.R. Ray, D.P. (2004). Geographical Indications of Plant Species in ITKs in Agriculture-5. Division of Agricultural Extension, ICAR, New Delhi. 266 pp.

42 Mishra, A., Singh, S.R.K., Raut, A.A. (2020). Traditional Knowledge in Agriculture. Division of Agricultural Extension, ICAR, New Delhi. 39 pp.

43 International Patent Classification (2025). International Patent Classification Codes. World Intellectual Property Organization. https://www.wipo.int/en/web/classification-ipc. Accessed on 01-03-2025.

44 World Intellectual Property Organization (WIPO) (2024). Agrifood. Patent Landscape Report Series. Geneva: WIPO. DOI: 10.34667/ tind.49840.

45 Anwer, Md.E., Padmaja, S.S., Kandpal, A. (2023). Trends and Patterns of Patent in Agriculture and Allied Sector. Journal of Intellectual Property Rights 28: 529-543. DOI: 10.56042/jipr.v28i6.4043.

46 Hellerer, U., Jarayaman, K. (2000). Greens persuade Europe to revoke patent on neem tree. Nature 405: 266–267.

47 Mulik, K., Crespi, J.M. (2011). Geographical Indications and The Trade Related Intellectual Property Rights Agreement (TRIPS): A Case Study of Basmati Rice Exports. Journal of Agricultural & Food Industrial Organization 9(1): 1-21. https://doi.org/10.2202/1542-0485.1336.

48 Spicyip (2018). The Himachal Pradesh High Court Revokes Patent Grant Invoking Section 3(p). De-Coding Indian Intellectual Property Law; https://spicyip.com/2018/07/the-himachal-pradesh-high-court-revokes-patent-grant-invoking-section-3p.html; last accessed on 01-03-2025

49 Kher, M.N., Sheth, N., Bhatt, V.D. (2022). Veterinary herbal formulation of *Terminalia chebula*. Indian Patent No. 409688, filled July 7, 2019, issued October 21, 2022.

50 Patil, P.N. (2017). Methods for improving milk letting down in milch animals. US Patent No. 9827284B2, filed September 26, 2014, issued November 28, 2017.

51 Patil, P.N. (2014). Herbal cattle feed supplement compositions for enhancing productivity and quality of milk. US Patent No. 8663623B2, filed October 12, 2009, issued March 04, 2014.