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Environmental Accounting

Explainer Series

Pollination Services

Government of India

Ministry of Statistics and Programme Implementation

National Statistical Office

Social Statistics Division

Acknowledgement

The Division gratefully acknowledges the contribution of all the source agencies, without whom this concept paper on valuation of pollination services could not have been possible.

Access

Soft Copies of this report and the tables contained therein are available for download, free of charge, from: https://www.mospi.gov.in/download-reports

Disclaimer

The contents of this publication are intended to enhance public access to information about pollination services.

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Feedback and suggestions for the publication are welcomed by the environment unit at **ssd-mospi@gov.in .**

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Government of India
Ministry of Statistics & Programme Implementation

Message

I am pleased to note the release of the ***Environmental Accounting Explainer Series on Pollination Services***, a publication that contributes to the National Statistical Office's continuing work on strengthening the measurement and communication of environmental-economic statistics and accounts.

Pollination underpins agricultural productivity, forest regeneration, biodiversity conservation, and food and nutritional security in India. A significant proportion of crops and forest plant species depend wholly or partially on animal-mediated pollination, making pollination indispensable for ecosystem resilience and economic activity. Despite its importance, pollination services have largely remained outside conventional economic measurement. This publication addresses this gap by presenting, for the first time, a dedicated and integrated national-level environmental accounting of pollination services.

The publication supports ongoing efforts to strengthen rigour and standardization in ecosystem service measurement. It links the ecological basis of pollination with official statistical compilation. Using internationally aligned accounting principles, it demonstrates estimation approaches based on crop dependence parameters and productivity methods anchored in national accounts. The framework provides a foundation for future refinements in coverage, data inputs, and analytical detail.

The publication could take its final shape largely due to the timely cooperation and inputs provided by the participating Ministries, Departments and Expert group. I also acknowledge the dedicated efforts of officers of the Social Statistics Division for compiling and bringing out this valuable document within a demanding timeframe.

I am confident that this publication will act as a useful reference for policymakers, planners, researchers, and all stakeholders engaged in environmental management and sustainable development.

Saurabh Garg
(Dr. Saurabh Garg)

New Delhi
March 3, 2026

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FOREWORD

The National Statistical Office remains committed to strengthening India's environmental statistics by expanding the scope and policy relevance of environmental-economic accounts. In this context, the ***Environmental Accounting Explainer Series on Pollination Services***represents an important step towards systematically recognizing a critical regulating ecosystem service within the System of Environmental-Economic Accounting (SEEA) framework.

Pollination is an important ecological process that supports agricultural production and contributes to the stability of production systems. By presenting pollination services within an accounting-oriented framework, the publication facilitates a structured understanding of how such services may be considered alongside conventional statistical outputs.

The report connects ecological evidence on pollination with environmental-economic accounting, drawing on inputs from agencies such as the ZSI (MoEFCC) and MoAFW and its allied Institute. It sets out SEEA-aligned methods to recognize, measure and value pollination services, using national accounts statistics. The year-wise estimates and Monetary Supply and Use Tables represent a key step towards integrating pollination services into official environmental-economic statistics and strengthening the evidence base for sustainable production and ecosystem resilience.

The preparation of this publication has been made possible through the cooperation of participating Ministries, Departments and Expert group. I acknowledge their contributions and appreciate the dedicated efforts of the officers of the Social Statistics Division, Ministry of Statistics and Programme Implementation, under the guidance of **Sh. S.C. Malik, Additional Director General.**

I am confident that this explainer series will serve as a valuable reference for policymakers, researchers, and other stakeholders and I welcome feedback to further strengthen future editions.

(N.K. Santoshi)

New Delhi
03rd March, 2026

Data for Development

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Preface

Pollination services, though not traditionally reflected in official economic statistics in India, play a critical role in sustaining agricultural production, forest regeneration, biodiversity conservation, and food and nutritional security. As a vital regulating ecosystem service, pollination underpins crop yields, quality, and ecosystem resilience. This ***Environmental Accounting Explainer Series on Pollination Services*** seeks to address existing gaps by presenting a structured framework for recognizing, measuring, and valuing pollination services within the System of Environmental-Economic Accounting (SEEA).

This publication represents a dedicated national-level effort aligned with the SEEA Ecosystem Accounting framework, integrating ecological information with environmental-economic accounting methodologies. Drawing on inputs from Ministry of Agriculture and Farmers welfare , National Accounts Division of MoSPI, Zoological Survey of India, the report elaborates valuation approaches based on dependence ratios and simplified applications of the Change in Productivity method using official national accounts statistics.

The report has been prepared by the Social Statistics Division (SSD), Ministry of Statistics and Programme Implementation, under the guidance of **Ms. Anita Baghel**, Deputy Director General. I acknowledge the valuable contributions of all participating organizations and appreciate the dedicated efforts of the officers of SSD involved in bringing out this publication.

It is hoped that this explainer series will serve as a useful reference for policymakers, researchers, and practitioners. Feedback and suggestions are welcome to further strengthen future editions.

New Delhi
March 3, 2026

(S.C. Malik)

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Acknowledgement

This publication, ***Explainer Series on Pollination Services***, presents a comprehensive and integrated statistical perspective on pollination as a vital regulating ecosystem service in India. Aligned with the System of Environmental-Economic Accounting (SEEA Ecosystem Accounting), the report brings together ecological foundations of pollination, the diversity and distribution of pollinators, and SEEA-consistent methodologies for recognising, measuring, and valuing pollination services. This publication demonstrates the substantial and growing contribution of pollination to agricultural output, biodiversity conservation, ecosystem resilience, and food and nutritional security, thereby strengthening the evidence base for informed policy-making and sustainable development planning.

I take this opportunity to express my heartfelt gratitude to **Dr. Saurabh Garg, Secretary, Ministry of Statistics and Programme Implementation (MoSPI); Sh. N.K. Santoshi, Director General (Central Statistics), MoSPI; and Sh. S.C. Malik, Additional Director General, Social Statistics Division, MoSPI**, for their visionary leadership, consistent guidance, and steadfast support, which have been pivotal in bringing out this publication. I also extend my sincere appreciation to the Central Ministries, Departments, and Organizations whose cooperation and timely data inputs formed the foundation of this work.

I am deeply grateful the members of the Expert Group on Environment Statistics for their valuable suggestions and expert guidance, which have significantly enhanced the conceptual clarity and quality of this publication. I would also like to place on record my sincere gratitude to **Dr. O.P. Chaudhary, Principal; and Dr. Ramesh Chand, Member of NITI Aayog;** for their seminal research work on crop-wise pollination dependency, which provided a robust scientific basis for the methodologies adopted in this report. Their research has been instrumental in developing the dependence-ratio-based bio-economic approach and in strengthening the valuation of pollination services presented in this publication.

I would further like to acknowledge the dedication and commitment of **Ms. Kirti Gaikwad, Joint Director; Ms. Neha Singh, Deputy Director; Shri Sourabh Kant, Deputy Director; Ms. Nikita Kumari, Junior Statistical Officer; Shri Rajeev Roshan, Junior Statistical Officer; Dr. Shivani Sinha, Consultant and Ms. Priya Mishra, Consultant** whose focused efforts and teamwork ensured the timely completion of this publication.

I hope that this explainer series will serve as a useful resource for planners, policymakers, researchers, and academicians working in the areas of agriculture, biodiversity, and environmental-economic accounting. Feedback and suggestions from readers will be valuable in further refining methodologies and expanding the scope of future editions.

(Anita Baghel)

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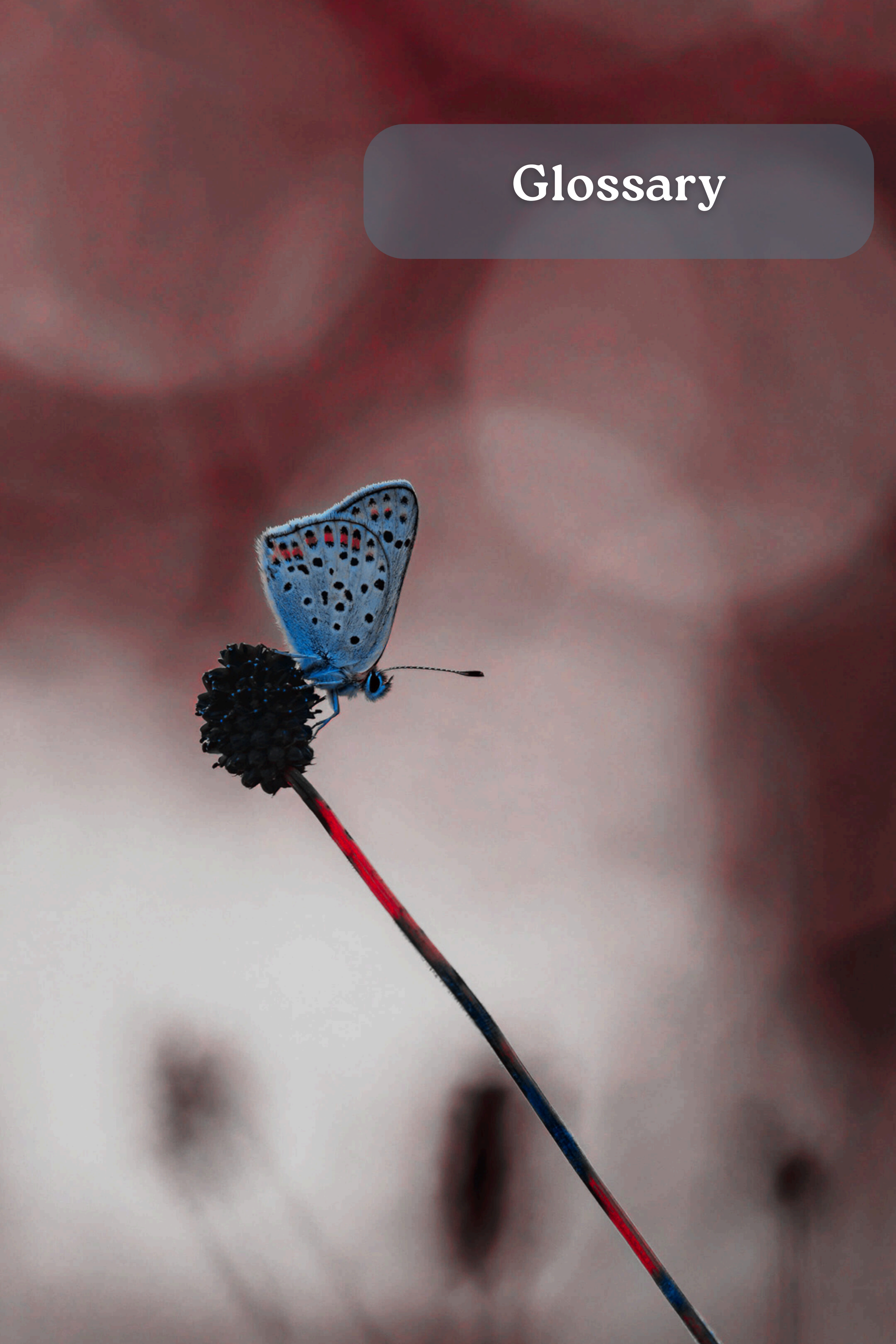
Acronyms and Abbreviations

- ABFPI – Agro Based and Food Processing Industries
- AI – Artificial Intelligence
- ARIES – Artificial Intelligence for Environment and Sustainability
- CCE – Crop Cutting Experiments
- CICES – Common International Classification of Ecosystem Services
- CVM – Contingent Valuation Method
- DCS – Digital Crop Survey
- DR – Dependence Rate
- EARAS – Establishment of an Agency for Reporting of Agricultural Statistics
- EA – Ecosystem Accounting
- ES – Ecosystem Services
- ESTIMAP – Ecosystem Service Mapping Tool
- EV – Economic Value
- EVP – Economic Value of Pollination
- FAIR – Findable, Accessible, Interoperable and Reusable
- FDA – Forest Development Agency
- FFPM – Forest fire Prevention and Management
- FHP – Farm Harvest Price
- FSI – Forest Survey of India
- GCES – General Crop Estimation Surveys
- GIM – The National Mission for a Green India
- GVO – Gross Value Output
- GVY – Gramodyog Vikas Yojana
- IPBES – Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
- ISFR – India State of Forest Report
- InVEST – Integrated Valuation of Ecosystem Services and Tradeoffs
- JFMCs – Joint Forest Management Committees
- KVIC - The Khadi and Village Industries Commission

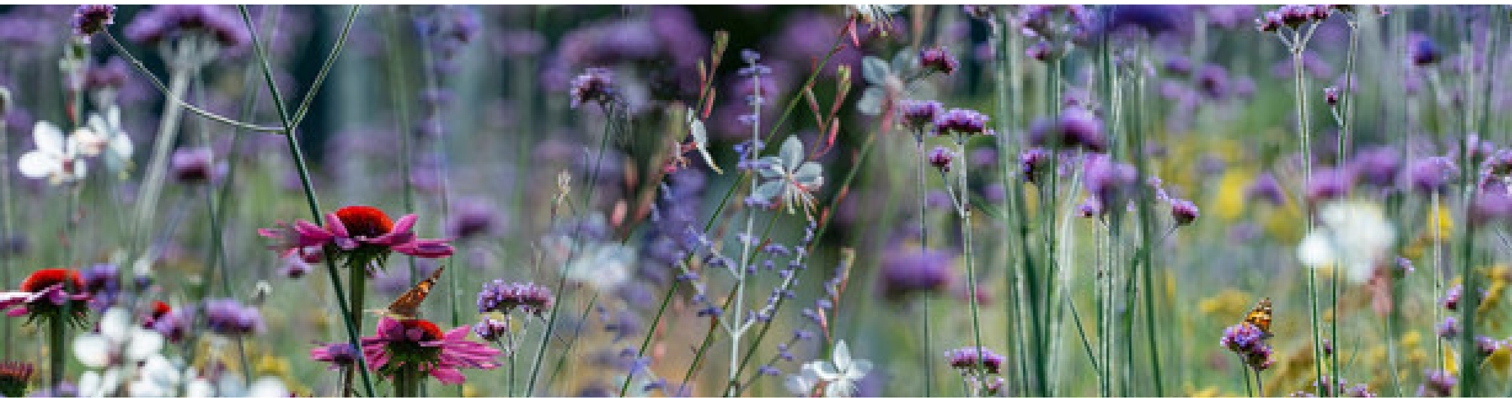
- LULC – Land Use / Land Cover
- MA – Millennium Ecosystem Assessment
- MoAFW – Ministry of Agriculture and Farmers Welfare
- MoSPI – Ministry of Statistics and Programme Implementation
- MSME – Ministry of Micro, Small and Medium Enterprise
- MSUT – Monetary Supply and Use Table
- NAP – National Afforestation Programme
- NAS – National Accounts Statistics
- NESCS – National Ecosystem Services Classification System
- NCP – Nature's Contributions to People
- NTFP – Non-Timber Forest Products
- PSUT – Physical Supply and Use Table
- PVO – Pollination Attributed Value of Output
- SEEA – System of Environmental-Economic Accounting
- SEEA-EA – System of Environmental-Economic Accounting – Ecosystem Accounting
- SFDA – State Forest Development Agency
- SNA – System of National Accounts
- SPA – Service Providing Areas
- TEEB – The Economics of Ecosystems and Biodiversity
- TRS – Timely Reporting Scheme
- UT – Union Territory
- VO – Value of Output
- WTA – Willingness to Accept
- WTP – Willingness to Pay
- ZSI – Zoological Survey of India

Glossary

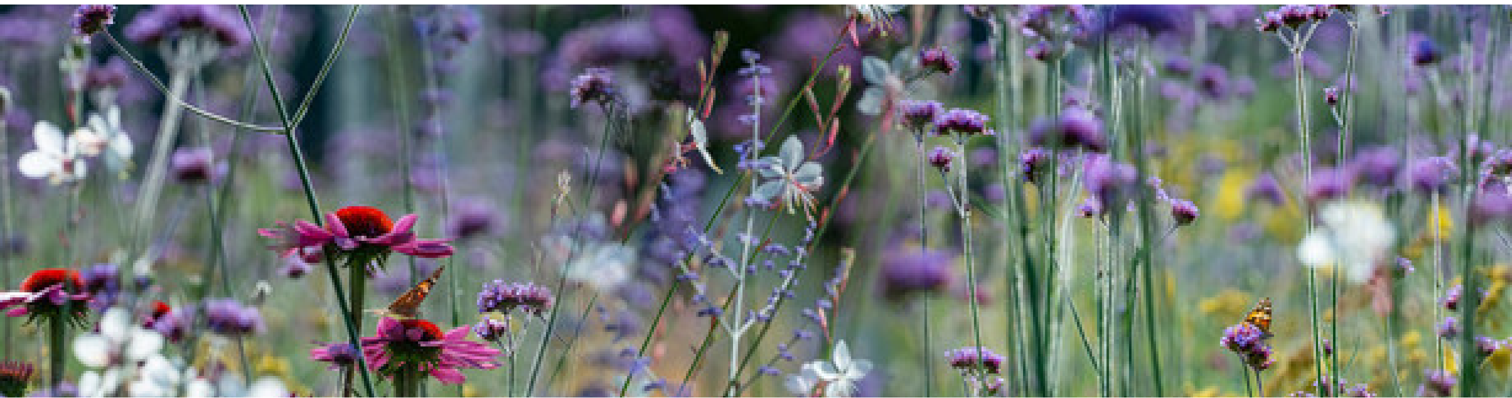


Glossary

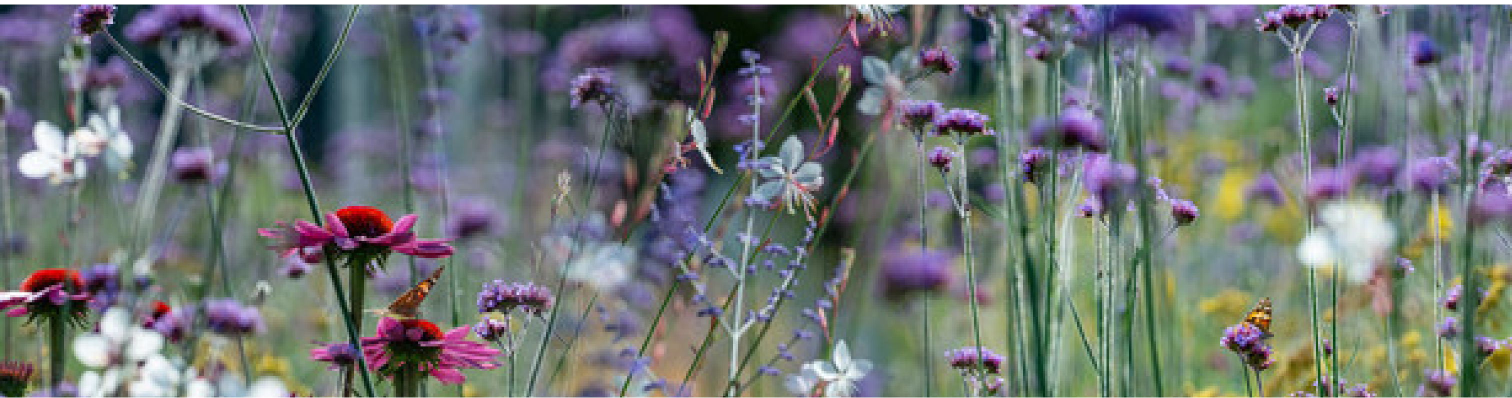
A	
Angiosperms	Flowering plants that produce seeds enclosed within fruits and constitute the primary biological basis for pollination interactions.
Animal Pollination	Pollination mediated by animals such as insects, birds and mammals, recognized as a regulating ecosystem service.
Anthers	Pollen-producing structures of flowers that release pollen for transfer during pollination.
B	
Biodiversity	Biodiversity or, “Biological diversity” means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
Biomass Provisioning Services	Ecosystem services resulting in the harvest of biological materials such as crops, timber and fibres.
Biotic Pollination	Pollination carried out by living organisms, primarily animals, as opposed to abiotic agents.
C	
Crop Pollination	Pollination carried out by living organisms, primarily animals, as opposed to abiotic agents.
Cross Pollination	Transfer of pollen between different plants of the same species, enhancing genetic diversity.



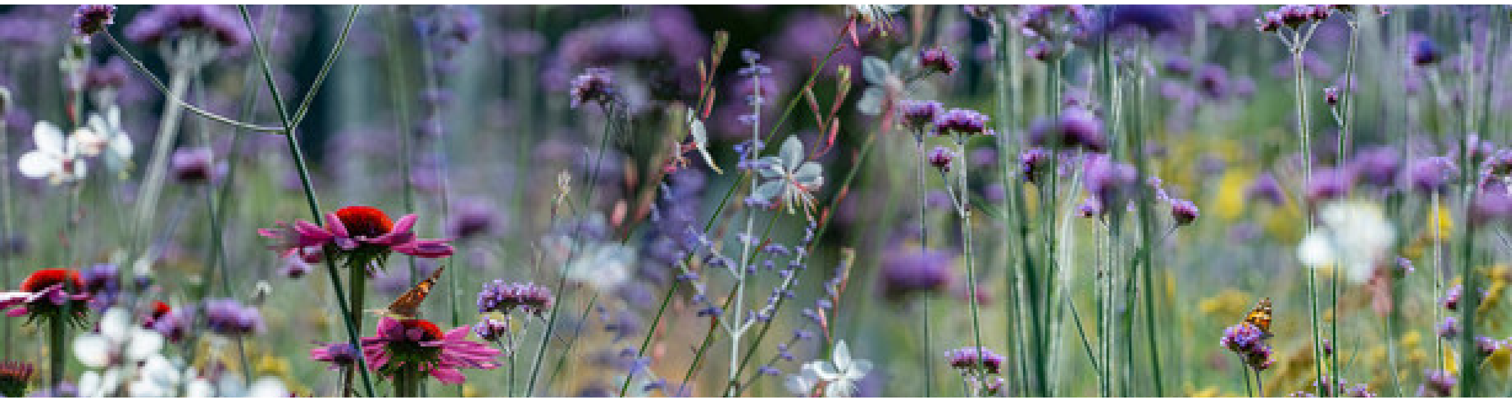
D	
Dependence Rate (DR)	The dependence rate (DR) represents the level of dependence of a crop on pollinators for fruit or seed production
E	
Ecosystem Accounting	Ecosystem accounting is a coherent framework for integrating measures of ecosystems and the flows of services from them with measures of economic and other human activity. Ecosystem accounting complements, and builds on, the accounting for environmental assets as described in the System of Environmental-Economic Accounting (SEEA) Central Framework (e.g. water resources, soil resources). In ecosystem accounting as described in the SEEA Ecosystem Accounting (SEEA EA), the accounting approach recognizes that these individual resources function in combination within a broader system and within a given spatial area.
Ecosystem Asset	Spatial areas comprising a combination of biotic and abiotic components and other elements which function together. Some examples are forests and wetlands.
Ecosystem Condition	Overall quality of an ecosystem asset in terms of its characteristics. Measures of ecosystem condition are generally combined with measures of ecosystem extent to provide an overall measure of the state of an ecosystem asset.
Ecosystem Extent	Size of an ecosystem asset, commonly in terms of spatial area.
Ecosystem Services	Benefits supplied by the functions of ecosystems and received by humanity.



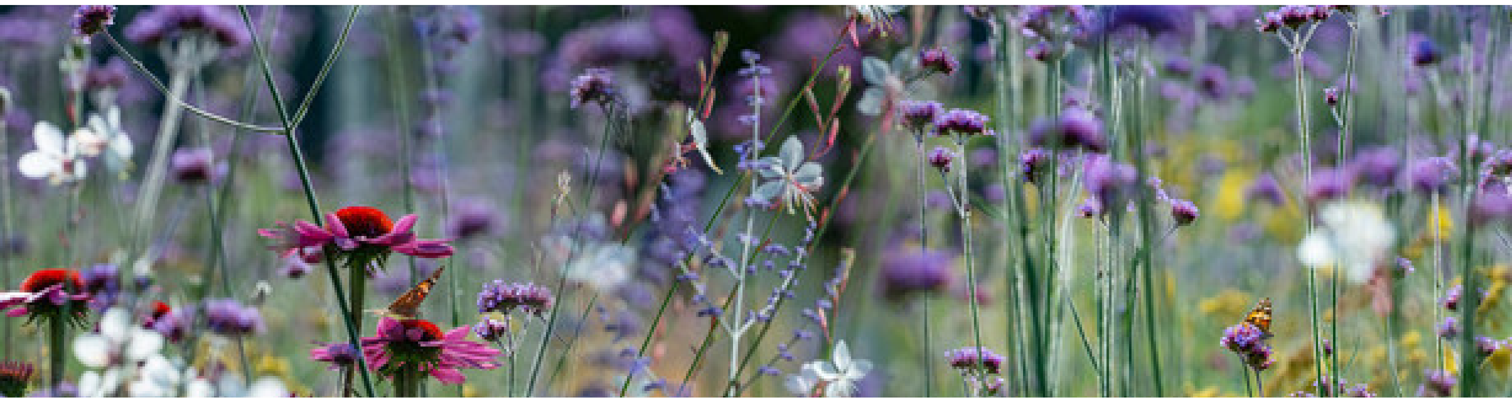
F	
Forest Pollination	Pollination processes within forest ecosystems supporting regeneration, biodiversity and forest products.
H	
Homozygosity	Presence of identical alleles at a genetic locus within an organism.
Heterozygosity	Presence of different alleles at a genetic locus, indicating genetic diversity.
I	
Intermediate Ecosystem Service	Those ecosystem services in which the user of the ecosystem services is an ecosystem asset and where there is a connection to the supply of final ecosystem services.
M	
Monetary Supply and Use Table (MSUT)	An accounting table that records ecosystem service flows in monetary terms, showing the supply of ecosystem services by ecosystem assets/ecosystem types and the corresponding use of those services by economic units/beneficiaries (including households).
N	
Natural Regeneration	Natural expansion / regression is an increase /decrease in area resulting from natural processes including seeding, sprouting, suckering, layering or erosion by sea. As in the case of managed expansion /regression, generally, the natural expansion of one land cover type will also lead to the recording of a matching entry for natural regression of another land cover type. A matching entry is not recorded if there is a natural expansion /regression in the total area of land (e.g., in the case where land is created through volcanic activity or landslide or eroded by sea).



O	
Obligate xenogamy	A reproductive system requiring cross-pollination for successful fertilization.
P	
Pollination	Pollination is the biological process through which pollen is transferred from the male reproductive structures of a flower (anthers) to the female structures (stigmas), enabling fertilization and subsequent seed and fruit formation.
Pollination Services	Regulating ecosystem services supporting agricultural production, forest regeneration and biodiversity.
Pollinator	A pollinator is an animal that helps to transfer pollen from one flower to another.
Pollination attributed Value of output (PVO)	Share of the total crop value attributable to pollinators
Provisioning Services	Those ecosystem services representing the contributions to benefits that are extracted or harvested from ecosystems.
Physical Supply and Use Tables (PSUT)	An accounting table that records ecosystem service flows in physical units, showing the supply of ecosystem services by ecosystem assets/ecosystem types (e.g., forests, cropland, grasslands) and the corresponding use of those services by economic units/beneficiaries (e.g., industries, households, government).
R	
Regulating and Maintenance Services	Those ecosystem services resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles and thereby maintain environmental conditions beneficial to individuals and society.



S	
Self-Pollination	Pollination occurring within the same flower or plant.
Stigma	The pollen-receiving structure of a flower enabling fertilisation.
Sustainable Development Goals (SDGs)	It is known as global goals, and are adopted as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace as well as prosperity by 2030. All United Nations Member States adopted these goals in 2015.
System of Environmental-Economic Accounting (SEEA)	The System of Environmental Economic Accounting (SEEA) is the accepted international standard for environmental-economic accounting, providing a framework for organizing and presenting statistics on the environment and its relationship with the economy. It brings together economic and environmental information in an internationally agreed set of standard concepts, definitions, classifications, accounting rules and tables to produce internationally comparable statistics. The SEEA is produced and released under the auspices of the United Nations, the European Commission, the Food and Agriculture Organization of the United Nations, the Organization for Economic Co-operation and Development, International Monetary Fund and the World Bank Group.
System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA)	The System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA) is a spatially based, integrated statistical framework for organizing biophysical information on ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity.
System of National Accounts (SNA)	The system of national accounts, abbreviated as SNA, is the internationally agreed standard set of recommendations on how to compile measures of economic activity in accordance with established accounting conventions based on economic principles.



V	
Valuation of Ecosystem Services	Estimation of ecosystem service values in monetary terms following SEEA principles.
Value of output of crops (VO)	The economic value of each crop and is calculated as the product of its total production (in tonnes) and its unit price (per tonne) at current prices.
X	
Xenogamy	Cross-pollination between different plants of the same species.

Executive Summary

Cross pollination is a fundamental biological process and a vital regulating ecosystem service that forms an integral component of India's natural capital, underpinning agricultural productivity, food and nutritional security, forest genetic health and ecology, regeneration and biodiversity conservation. Through the transfer of pollen from anthers to stigmas, pollination enables genetic diversity, fertilization, seed formation, and fruit set-development in the majority of wild and cultivated flowering plants. A substantial proportion of India's food crops, horticultural species, and forest plants depend wholly or partially on animal pollinators such as bees, butterflies, moths, flies, beetles, birds, and bats, making pollination indispensable for ecosystem resilience and economic activity. In this context, national initiatives aligned with the System of Environmental-Economic Accounting (SEEA) increasingly emphasize the need to systematically recognize and integrate pollination services that benefit both natural and agro-ecosystems into environmental and natural capital accounts to enable comprehensive assessment of ecosystem contributions and support informed sustainable policy and development planning.

This report is compiled as a dedicated effort to present an integrated statistical perspective on pollination services. For the first time, the report brings together a dedicated, compiled, and detailed account exclusively focused on crop pollination services, enabling a structured and in-depth presentation of information across multiple dimensions, including through the development of Monetary Supply and Use Tables (MSUT). The report presents an account of pollination in India in which the valuation of crop pollination services is provided, while forest and other ecosystems pollination services are addressed at the methodological level, marking a significant advancement in integrating environmental and economic statistics.

The report presents a comprehensive assessment of pollination as a critical ecosystem service, combining ecological understanding with environmental-economic accounting. It explains pollination biology, modes of cross pollination and the diversity and distribution of pollinators in India, establishing a strong ecological foundation for accounting applications. Drawing on inputs from agencies such as the Zoological Survey of India, it documents the diversity of natural and managed pollinators, with particular emphasis on insect pollinators, while also recognizing the complementary roles of bats, birds and other vertebrates across agricultural, forest and semi-natural ecosystems. The report elaborates methodologies for recognizing, measuring and valuing pollination services in line with the SEEA Ecosystem Accounting framework. It presents the valuation of pollination services delivered by both wild and managed pollinators. A key contribution is the year-wise analysis of crop pollination services, which highlights trends, crop-specific variations and the changing contribution of pollination to agricultural production over time. By examining linkages with the Sustainable Development Goals and broader policy priorities, the report provides a robust evidence base to support sustainable agriculture, biodiversity conservation, ecosystem resilience and integrated environmental-economic planning.

Key findings

Pollination-attributed value of output (PVO) rises substantially over the decade. Total PVO increases from ₹115.41 ('000 crore) in 2012–13 to ₹266.33 ('000 crore) in 2021–22, with a marked acceleration after 2018–19.

Fruits and vegetables remain the dominant contributor to total PVO of crops. The PVO for fruits and vegetables increases from ₹47.46 ('000 crore) in 2012–13 to ₹117.25 ('000 crore) in 2021–22, and continues to account for the largest share of total PVO over time.

Oilseeds constitute the second-largest component and show strong expansion. Oilseeds PVO rises from ₹36.40 ('000 crore) to ₹85.06 ('000 crore) over the decade, indicating a significant and growing pollination-attributed contribution for this category in absolute terms.

Within Category-level PVO shares indicate highest reliance on pollinator is for oilseeds and fibres. The heatmap analysis shows that oilseeds consistently record the highest PVO share in their category value of output (approximately 27–32%), followed by fibres (approximately 22–23%). Fruits and vegetables remain broadly stable (approximately 13–15%), while condiments and spices show a declining share over time.

Pollination forms a stable but slightly increasing **share of total crop output value**. The aggregate pollination-attributed share of total crop output remains broadly within the 8-10% range and rises towards the end of the period, reaching its highest level in 2021–22 (around 9.6%).

Selected crop examples show that both high dependence and scale of production shape PVO. For fruits and vegetables, large increases are observed for widely consumed crops such as guava, orange, watermelon, apple, mango, tomato, and several cucurbits, reflecting the combined influence of dependence rates and production magnitude on pollination-attributed values. These crops are important for nutritional health due to their vitamin content.

Integration into an The Monetary Supply and Use Table (MSUT) framework formalizes pollination as an ecosystem service flow, with defined current boundaries. The MSUT records pollination service supply from cropland and allocates use to agriculture, with matched values of ₹115.41 (‘000 crore) (2012–13) and ₹266.33 (’000 crore) (2021–22).

The valuation results show that pollination contributes a substantial and rising share of crop output, with the largest economic exposure concentrated in fruits & vegetables, oilseeds, and condiments & spices over 2012-13 to 2021-22. This provides a clear policy rationale for strengthening beekeeping and pollination-support programmes- the National Beekeeping & Honey Mission (NBHM) with a multi–mini-mission design, the Mission for Integrated Development of Horticulture (MIDH), and the KVIC Honey Mission- as these interventions generate direct livelihood benefits (honey and allied products) while also safeguarding crop productivity and quality through improved pollination. Given the scale of pollination-attributed value, even modest improvements in pollinator management and habitat conditions can yield high economic returns. Accordingly, integrating pollinator-friendly practices into agricultural schemes and sustaining habitat-supporting measures in forest and landscape programmes are essential for long-term production resilience and food security.

Chapter-1

Pollination : Foundation, Functions and Frameworks

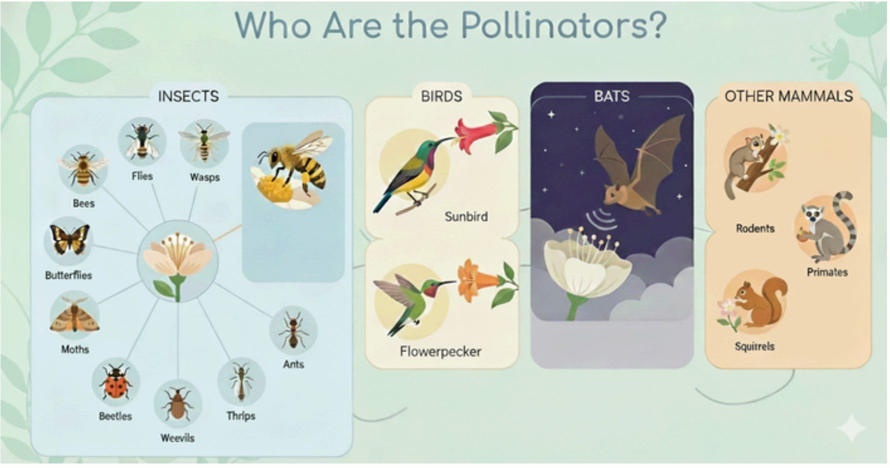
Pollination: A Biological Process

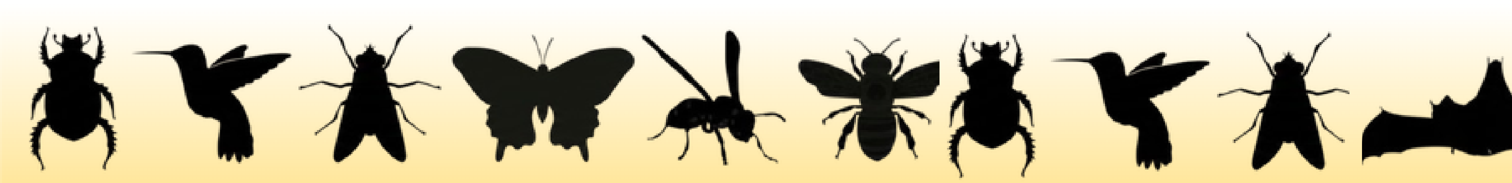
1.1 Pollination is the biological process through which pollen is transferred from the male reproductive structures of a flower (anthers) to the female structures (stigmas), enabling fertilization and subsequent seed and fruit formation. The majority of cultivated and wild flowering plants (angiosperms) do not complete their life cycle without successful pollen transfer, and this transfer is frequently mediated by external agents such as animals, wind or water and is called cross-pollination. As a result, pollination is simultaneously a reproductive event at the level of individual plants and an ecosystem process at the level of plant communities.

1.2 From an ecological perspective, pollination underpins the persistence and evolution of angiosperms. Animal-mediated pollination, in particular, is indispensable for a large share of global food production, because fruit and seed formation in many crops depends on the movement of viable pollen grains from one flower to another. Where plants cannot self-pollinate efficiently, the dependence on external pollination vectors is especially pronounced, making pollination a prerequisite for both natural and cultivated vegetation.

1.3 Pollinators visit flowers not with the explicit “intention” of pollination, but to obtain nutritional and other rewards. Flowers supply nectar as an energy-rich sugar source, pollen as a source of proteins, lipids, vitamins and minerals, and in some specialized systems, oils, fragrances and resins. These resources are used by a wide range of animals, insects, bats, birds and other mammals for feeding, reproduction and nest construction. In the course of feeding and foraging, these animals pick up pollen on their bodies and deposit it on other flowers, thereby incidentally completing the pollination process. This ecological interaction benefits both partners and illustrates the tight coupling between plant reproductive strategies and animal foraging behavior.

1.4 The range of pollinating animals is taxonomically diverse. Insects are dominant, particularly bees, but flies, wasps, butterflies, moths, beetles, weevils, thrips and ants also contribute significantly.





Among vertebrates, bats, birds and several non-flying mammals, including primates and small rodents, act as regular pollinators in many ecosystems. This diversity of pollinator taxa is mirrored by an equally wide variety of floral forms, colours, scents and reward types. The co-occurrence of such floral and pollinator diversity reflects long evolutionary histories in which plant and pollinator traits have been shaped in response to each other, producing a range of specialized and generalized pollination systems.

Types of Pollination

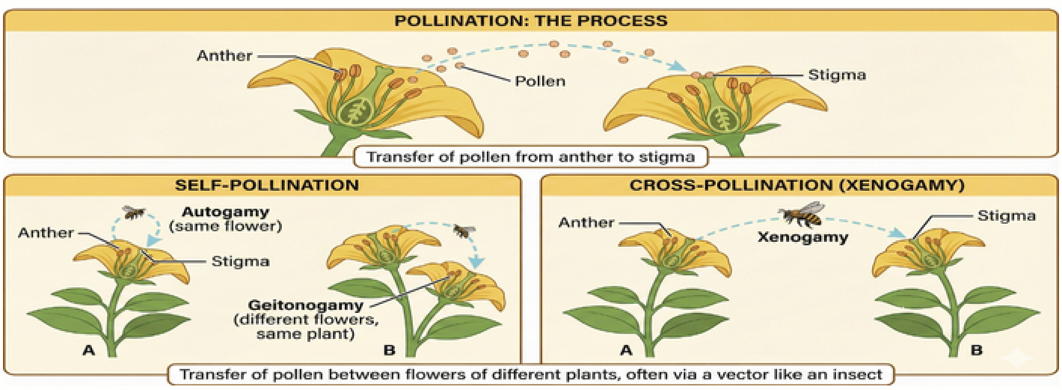
1.5 Pollination is classified based on the origin and destination of pollen grains. A broad distinction is made between self-pollination (selfing) and cross-pollination (outcrossing), both of which are essential for plant reproduction and evolutionary adaptation. In self-pollination, pollen is transferred from anthers to stigmas of the same flower or of different flowers on the same plant. In cross-pollination, pollen comes from a different individual of the same species. Selfing tends to increase homozygosity and may, over generations, reduce genetic variability, whereas outcrossing promotes heterozygosity, gene recombination and the potential for adaptive responses under changing environmental and pest-pressure conditions.

1.6 Within this broad classification, plant reproductive systems can be further differentiated. Obligate xenogamy requires pollen to come from a genetically distinct individual and is typical of many fruit crops. Self-pollination itself has two forms: autogamy, in which pollen moves within the same flower, and geitonogamy, in which pollen is transferred between flowers on the same plant. In addition, mixed mating systems occur where facultative xenogamy, geitonogamy and autogamy combine in different proportions across cultivars and species. This spectrum of mating systems reflects both the opportunities and constraints presented by local pollinator assemblages, climate and habitat structure.

1.7 Some plant species, including economically important crops, reduce or bypass their dependence on pollinators through mechanisms such as automatic self-pollination, agamospermy (apomixis) and parthenocarpy. In agamospermy, seeds form without fertilization, while in parthenocarpy fruits develop without seed formation. These mechanisms are particularly important in cereals and some fruit crops, where seed or fruit production can occur in the absence of effective pollination. Even in such cases, however, pollination remains critical at landscape scale because associated wild vegetation, fodder species and many complementary crops depend strongly on pollinator activity.

1.8 Types of pollination as given in Fig. 1 can thus be summarized as follows. Self-pollination or selfing occurs when flowers are bisexual, anthers and stigma are positioned at similar heights, both sex organs mature at the same time, and dehiscing anthers come into contact with receptive stigmas. Under such conditions, pollen transfer within the same flower or plant is sufficient to achieve fertilization, often with minimal involvement of external agents. In contrast, cross-pollination requires that pollen grains be transported from one flower to another, eg as happens when bees are foraging (Fig 1), frequently between different individual plants; here, vectors such as wind, water or animals are indispensable.

Figure 1: Types of Pollination[1]



1.9 The choice between selfing and outcrossing is not merely a mechanistic issue but has deep ecological and evolutionary implications. Repeated selfing can lead to inbreeding depression in species that are naturally outcrossing, manifesting as reduced vigour, lower reproductive success and diminished survival. Conversely, outcrossing increases genetic variation and enhances the capacity of populations to respond to environmental fluctuations, novel pests and diseases. This balance between reproductive assurance through selfing and genetic renewal through outcrossing is central to understanding plant population dynamics, crop improvement strategies and long-term ecosystem resilience.

1.10 Against this background, pollination can be seen as more than a simple transfer of pollen; it is a structuring process that shapes plant genetic structure, reproductive success and adaptive potential. It provides the biological underpinning for later discussions on

[1] IPBES (2016). The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. S.G. Potts, V. L. Imperatriz-Fonseca, and H. T. Ngo (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 552 pages.

pollination modes, pollinator communities and the ecological and economic relevance of pollination in both agro-ecosystems and natural forests.

Pollination Modes and Pollinators

1.11 The actual movement of pollen from anther to stigma is accomplished through distinct pollination modes, each associated with particular agents and ecological settings. Two broad categories are recognised: abiotic pollination, where non-living physical forces such as gravity, water and wind move pollen, and biotic pollination, where animals act as pollen vectors. In all cases, the organism or process that brings about pollen transfer is referred to as the pollinator or pollinating agent. The relative importance of each mode varies across habitats, plant functional types and climatic zones.

Abiotic Pollination

1.12 **Wind Pollination (Anemophily):** Wind pollination occurs in plant families such as Poaceae (grasses) and several temperate trees. The flowers are small, inconspicuous, and lack color, scent, or nectar. The pollen grains are light, dry, and produced in abundance, enabling dispersal over long distances. The stigmas are feathery and exposed to capture airborne pollen efficiently. Although this mode is less precise than animal-mediated pollination, it is advantageous in open environments where air movement facilitates pollen transport. In ecosystems dominated by grasses and cereal crops, wind pollination plays a major role in ensuring seed production. Crops such as rice, wheat, maize, and barley are primarily anemophilous. The efficiency of wind pollination depends on factors such as plant density, wind velocity, and atmospheric humidity.

1.13 **Water Pollination (Hydrophily):** Hydrophily is found in aquatic plants such as Vallisneria, Hydrilla, and Zostera. In some species, pollen grains are released on the water surface and carried to female flowers (epihydrophily), while in others, pollination occurs beneath the surface (hypohydrophily). Adaptations include hydrophobic pollen grains, long filamentous stigmas, and male flowers that detach and float towards female counterparts. Hydrophily, though rare, is significant in aquatic ecosystems as it demonstrates the adaptability of plants to different habitats. The process ensures reproduction even in environments where insects are scarce or absent.

1.14 **Gravity Pollination (Geophily):** In certain small, self-pollinating plants, pollen grains fall directly from the anther onto the stigma due to gravitational pull. Though limited in occurrence, this mechanism provides reproductive assurance where environmental conditions do not favor biotic or wind pollination.

Biotic Pollination

1.15 **Biotic pollination (zoophily**) is mediated by animals and is typically highly targeted and efficient. Because animals can transport small quantities of pollen accurately between flowers, plants that depend on zoophily often produce less pollen overall, but invest more in floral traits that attract and reward pollinators. Such traits include bright colours, distinctive scents, nectar production and floral shapes adapted to specific pollinator groups. In return for these rewards, pollinators provide a directed transfer of pollen that greatly enhances the probability of successful fertilization per pollen grain produced. Biotic pollination can be sub-classified on the basis of the taxa that act as pollinators. They are:

1.16 I**nsect Pollination (Entomophily):** The majority of flowering plants depend on insects for pollination. Insects are attracted to flowers by color, scent, and nectar. Their movements facilitate the transfer of pollen between flowers of the same species.

1.17 **Bees (Melittophily):** Bees are considered the most effective pollinators due to their morphological and behavioral characteristics. More than 70% of Crop plants rely upon bee pollination. Their specialized pollen hairs, known as scopa along with hairy bodies collect pollen efficiently, and their tendency to visit specific flower types increases pollination precision. Both wild and managed bees, including *Apis cerana indica* and *Apis mellifera*, are vital for pollination of crops such as apple, mustard, and sunflower. Bee-mediated pollination occupies a special place among biotic modes. Bees utilise flowers primarily as food sources, collecting both nectar and pollen, and show high “floral constancy”, repeatedly visiting flowers of the same species during a foraging bout. This behaviour greatly increases the efficiency of conspecific pollen transfer. Most of the 21,000 bee species worldwide act as effective pollinators.

1.18 **Butterflies (Psychophily) and Moths (Phalaenophily):** Butterflies pollinate brightly colored flowers with flat surfaces suitable for landing, while moths prefer white or pale-colored flowers that emit strong fragrances at night. Both groups contribute significantly to maintaining floral diversity.

1.19 **Beetles (Cantharophily):** Beetles pollinate large, bowl-shaped flowers often containing exposed pollen. They are important pollinators in tropical forests, where they assist in the reproduction of primitive angiosperms.

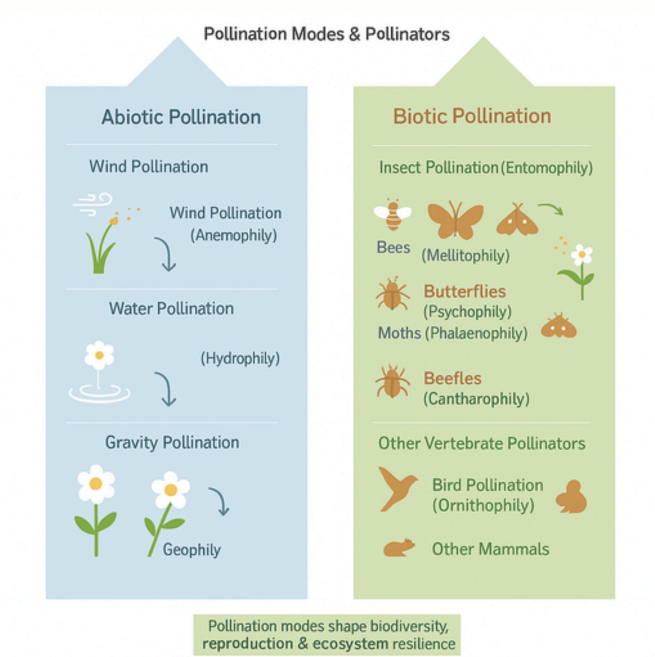
1.20 **Flies (Myophily):** Flies visit dull-colored flowers with strong odors and play a supplementary role in pollination, especially in cooler regions where bees are less active.

1.21 **Bird Pollination (Ornithophily):** Birds such as sunbirds pollinate brightly colored, tubular flowers that produce copious nectar. Pollen adheres to their feathers and beaks as they feed, ensuring efficient transfer. Bird pollination contributes to the reproduction of several tropical and subtropical plant species.

1.22 **Bat Pollination (Chiropterophily)**: Bats serve as nocturnal pollinators for flowers that are large, white or yellow, and strongly scented. These flowers produce abundant nectar to attract bats. Chiropterophily is crucial in maintaining the productivity of tropical ecosystems and supports the pollination of economically valuable fruit species.

1.23 **Other Vertebrate Pollinators:** Certain mammals such as squirrels, monkeys, and rodents, and even snails in humid environments, also assist in pollination. Though less common, their role underscores the diversity of pollination strategies in nature.

Figure 2: Pollination modes & Pollinators



1.24 Healthy pollination services are best secured by maintaining both the abundance and diversity of pollinators. Specialised relationships between particular plants and pollinators are often highlighted, but in practice, robust pollination at ecosystem scale depends on a rich assemblage of pollinators capable of buffering fluctuations in any single species. This diversity promotes stable seed set, maintains genetic variability in plant populations and contributes to the resilience of both natural and agricultural systems under environmental change.

1.25 Pollination modes and their associated pollinators therefore do not merely differ in mechanics; they generate distinct patterns of gene flow, floral diversity and ecosystem functioning. Selfing and wind pollination can lead to genetic simplification and restricted floral variation, while animal-mediated pollination is tightly linked to high floral diversity, complex plant–animal networks and the emergence of specialized reproductive niches. These differences are central to understanding the ecological and evolutionary consequences of pollination systems, especially when assessing the impacts of pollinator decline.

Relevance of Pollination

Ecological importance

1.26 Pollination is widely recognised as a keystone process in terrestrial ecosystems. Most flowering plants produce viable seeds only if pollen is transferred successfully from anthers to stigmas, and this often depends on animal pollinators. If this service fails, multiple linked processes, plant reproduction, seed and fruit production, recruitment of seedlings and the provision of food and habitat for other organisms, can be disrupted. With hundreds of thousands of plant species relying on pollinators, the integrity of pollination processes is fundamental for maintaining biodiversity at genetic, species and ecosystem levels.

1.27 Pollination strongly shapes plant community composition. Animal pollinators, by enabling many flowering plant species to coexist, prevent landscapes from becoming dominated solely by a few wind-pollinated taxa. As a result, pollination services influence which plant species are present, how abundant they are and how they are spatially arranged. This, in turn, determines the availability of fruits, seeds and floral resources for a wide array of other organisms, including frugivores, granivores and nectar-feeding animals.

Through these pathways, pollination contributes to the structure of food webs and to the maintenance of ecosystem functions such as nutrient cycling and habitat formation.

1.28 The ecological implications of different pollination modes are far-reaching. Repeated selfing can lead to genetic impoverishment and reduced adaptive capacity, whereas outcrossing supported by animal pollinators promotes genetic diversity and facilitates responses to environmental challenges. Wind pollination offers some scope for genetic recombination but is associated with lower floral diversity and a more restricted set of morphological traits. By contrast, zoophily is associated with high floral diversity, a wide spectrum of pollination syndromes and enhanced opportunities for speciation. In species-rich communities, such as tropical and Mediterranean ecosystems, biotic pollen dispersal predominates and supports intricate, long-term co-evolution between plants and pollinators.

1.29 The mutual adaptation of flowers and pollinators reflects these co-evolutionary histories. Floral forms, colours, scents and reward patterns bear the imprint of selective pressures exerted by pollinators, while pollinator morphology and behaviour have been shaped by the need to efficiently exploit floral resources. Paleontological evidence suggests that many present-day flower forms arose through prolonged interactions with pollinators over geological timescales. This interdependence reinforces the idea that the decline of pollinator diversity or abundance could have cascading effects on plant evolution, community composition and ecosystem stability.

1.30 In forest and other semi-natural ecosystems, pollination also governs regeneration processes apart from fostering and maintaining genetic diversity. Natural regeneration, fruiting patterns and the re-establishment of tree and understory species after disturbance are tightly connected to pollination and seed dispersal. Forests provide habitats for native pollinators, while pollinators in turn secure the reproductive continuity of forest species. Pollination therefore contributes to the maintenance of vegetation cover, soil protection and the resilience of forest ecosystems to environmental shocks.

1.31 From an ecosystem-service perspective, pollination is recognised as a regulating service associated with “lifecycle maintenance, habitat and gene pool protection”. It complements provisioning services (such as food, fibre and timber) and supporting services (such as nutrient cycling), by ensuring that the plant populations that generate these services remain viable across generations. Insufficient pollination can lead to reduced seed set, lower recruitment, local extinction of plant species and subsequent declines in animal populations that depend on their fruits or seeds, ultimately undermining ecosystem health.

Economic importance

1.32 Beyond its ecological role, pollination has substantial economic significance, particularly through its contribution to agriculture and food security. Pollinators are essential for the production of fruits, vegetables, oilseeds, forage crops, medicinal plant products and for the seed production of many root and fibre crops. A large proportion of the crop species that feed the world, as well as many plant-derived medicines, depend on animal pollination to produce healthy fruits and seeds. In terms of global food supply, about two-thirds of major food crops benefit from animal-mediated pollination, and a significant subset is specifically bee-pollinated[2].

1.33 The contribution of pollination to human nutrition goes beyond crop yield volumes. Pollination supports the diversity and quality of food available to people by enabling the production of fruits, nuts, seeds and vegetables rich in vitamins, micronutrients and beneficial phytochemicals. Animal-pollinated foods, therefore, play an important role in dietary diversity and in preventing hidden hunger associated with micronutrient deficiencies. Any decline in pollination services can thus have implications not only for caloric intake but also for nutritional security, particularly in regions where fresh fruits and vegetables are central to diets.

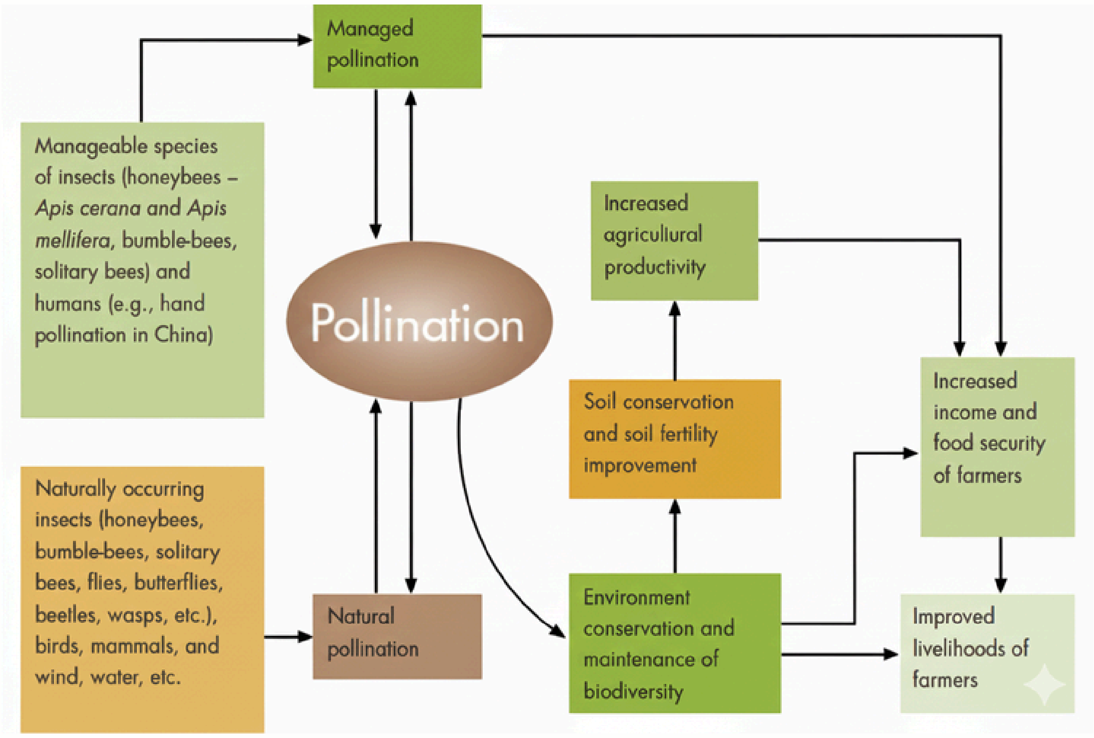
1.34 At the landscape level, pollination enhances crop productivity by improving both yield and quality. Adequate pollinator abundance and diversity increase the number of fruits or seeds set per plant, improve their size and shape, and often enhance their nutritional content and market value. Inadequate pollination, on the other hand, is associated with lower yields, misshapen fruits and reduced economic returns to farmers. Pollination is therefore sometimes described as a "third production factor" in agriculture, alongside soil and water, and is as critical as other agricultural inputs such as fertilizers and plant protection measures.

[2] Klein Alexandra-Maria, Vaissière Bernard E, Cane James H, Steffan-Dewenter Ingolf, Cunningham Saul A, Kremen Claire and Tscharntke Teja 2007Importance of pollinators in changing landscapes for world cropsProc. R. Soc. B.274303–313 http://doi.org/10.1098/rspb.2006.3721

1.35 Pollination also supports a range of non-food economic activities. Pollinator-dependent plants provide fibres (such as cotton and linen), biofuels (such as oilseed crops), medicinal products and construction materials like timber. In addition, livelihoods directly based on pollinators, notably beekeeping and honey hunting, form important components of rural economies in many regions. Income from honey, beeswax and other hive products supplements agricultural earnings and can provide a buffer against crop failure, thereby enhancing household resilience.

1.36 The economic value of pollination is thus embedded in multiple sectors: primary agriculture, processing industries, trade and rural employment. Even where precise monetary valuations differ across regions and crops, the qualitative conclusion is robust – pollination significantly augments the value of agricultural and forest outputs. Because these benefits depend on living pollinator populations and functional habitats, they link directly to conservation and sustainable management of ecosystems that host pollinators.

Figure 3: Importance of Pollination[3]



[3] Partap, U; Partap, T; Sharma, HK; Phartiyal, P; Marma, A; Tamang, NB; Ken, T; Munawar MS (2012) Value of insect pollinators to Himalayan agricultural economies. Kathmandu: ICIMOD

1.37 Pollination contributes indirectly to long-term economic stability by supporting environmental sustainability. By maintaining floral and habitat diversity, pollination helps conserve soil, regulate nutrient cycling and sustain genetic resources that are essential for future crop breeding and adaptation. These ecological functions reduce the risk of productivity losses under climate variability and emerging pest and disease threats. As such, protecting pollinators and pollination services is not only a biodiversity imperative but also an investment in the resilience of agricultural systems, forest ecosystems and the broader economy.

Pollination Services and the Sustainable Development Goals

1.38 The adoption of the 2030 Agenda for Sustainable Development has placed renewed emphasis on the interdependence between biodiversity, ecosystem services and human well-being. Pollination, as a key regulating ecosystem service, occupies a central position in this framework because it simultaneously supports food production, income generation, health, climate regulation and biodiversity conservation. Pollinators are directly or indirectly linked to **58 of the 169 SDG targets across 14 of the 17 Goals[4],** indicating that progress towards the SDGs is closely intertwined with the conservation and sustainable management of pollinators and their habitats. It may be noted that the discussion presented in the succeeding sub-sections is only an indicative account, prepared on the basis of the available literature and may other SDGs could also indirectly relate to pollinators or pollination services.

1.39 Within the SDG framework, **Zero Hunger (SDG 2) and Life on Land (SDG 15)** are most visibly connected to pollination. Approximately three-quarters of global food crops benefit, to varying degrees, from animal pollination, including many nutrient-rich fruits, vegetables and oilseeds. Ensuring access to sufficient, safe and nutritious food **(Targets 2.1 and 2.2)** and doubling the productivity and incomes of small-scale food producers **(Target 2.3 and 2.4)** depend, in part, on maintaining robust pollination services that increase yield, enhance crop quality and stabilise production under variable climatic conditions. At the same time, the conservation and restoration of terrestrial ecosystems and biodiversity **(Targets 15.1, 15.2, 15.3, 15.4, 15.5 and 15.9)** require viable pollinator populations to secure plant reproduction, natural regeneration and long-term ecosystem integrity.

[4] https://www.safeguard.biozentrum.uni-wuerzburg.de/Project/PublicFileSystem/media/others/SAFEGUARD_COP15_PolicyBrief.pdf

1.40 Pollination also contributes to **No Poverty (SDG 1)** through income diversification and livelihood enhancement. Beekeeping and other pollinator-based enterprises provide additional income streams from honey, beeswax and related products, while improved yields of pollinator-dependent crops raise farm incomes and support rural employment. These contributions acts as a pathways to poverty reduction **(Targets 1.1 and 1.2),** livelihood resilience **(Target 1.5)** and more equitable access to productive natural resources **(Target 1.4)**, especially for smallholders, indigenous communities and women.

1.41 The health dimension of pollination is reflected in **Good Health and Well-Being (SDG 3)**. Pollinator-dependent crops supply a substantial share of vitamins, micronutrients and bioactive compounds that underpin balanced diets and help prevent non-communicable diseases. In addition, bees and other pollinators support the regeneration of medicinal plants and provide raw materials such as honey, propolis and royal jelly used in traditional and modern pharmacopoeias **(Targets 3.4, 3.8 and 3.9)**. Reductions in pollinator populations can therefore translate into diminished nutritional diversity and restricted access to affordable natural health products, particularly for vulnerable groups.

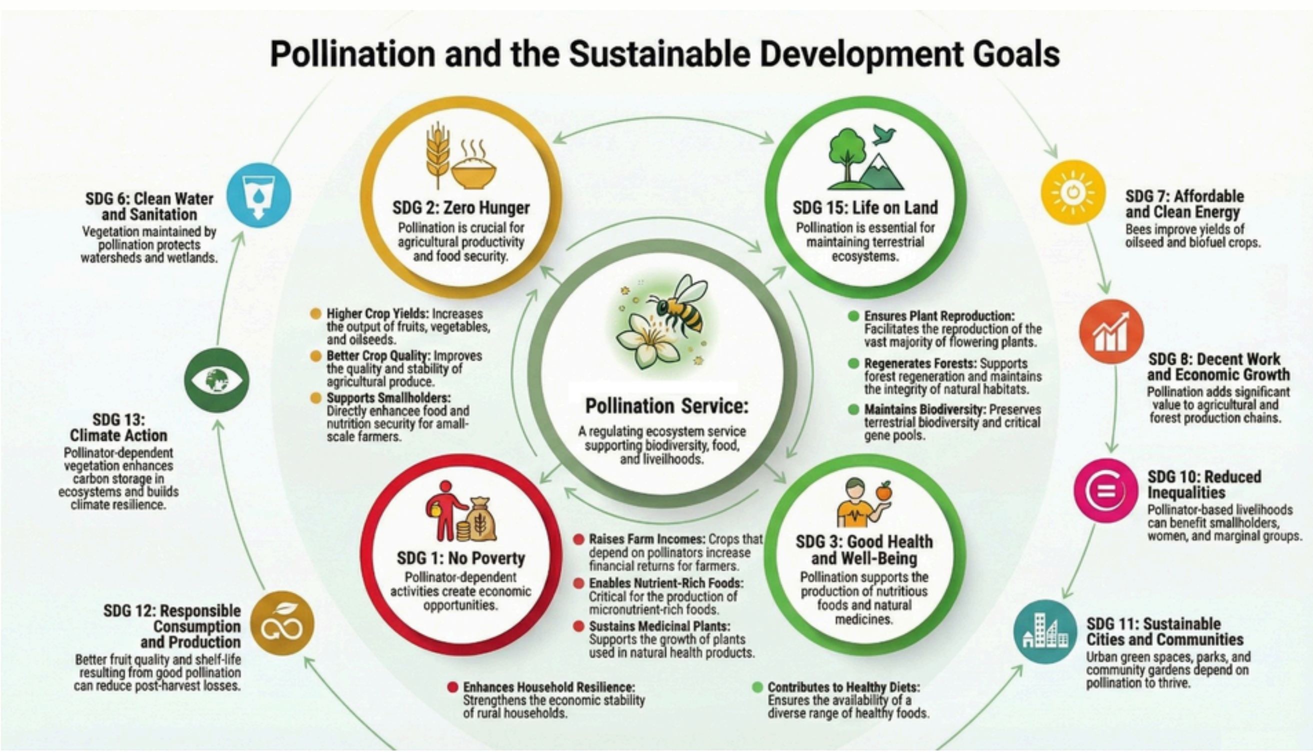
1.42 Pollination contributes to **Affordable and Clean Energy (SDG 7)** through its influence on the productivity of biofuel crops. Several oilseed crops used for biofuel production, such as canola and other oilseeds, exhibit higher yields and improved seed set when visited by bees, even where some self-pollination occurs. Enhanced yields from bee-assisted pollination strengthen the viability of biofuel feedstocks **(Target 7.2),** while diversified farming systems combining energy crops with pollinator-friendly habitats can generate co-benefits for energy security, rural development and biodiversity.

1.43 The economic and employment dimensions of pollination are reflected in **Decent Work and Economic Growth (SDG 8) and Reduced Inequalities (SDG 10).** Pollination-induced increases in agricultural productivity contribute to national income **(Target 8.1)**, while beekeeping and associated value chains create opportunities for productive employment and entrepreneurship, particularly in rural areas **(Target 8.6**). Where access to pollinator-based enterprises and pollinator-dependent high-value crops is extended to marginalised groups, these activities can promote more inclusive patterns of growth and help narrow income disparities **(Targets 10.1 and 10.2)**.

1.44 Urban and peri-urban pollination is pertinent to **Sustainable Cities and Communities (SDG 11) and Responsible Consumption and Production (SDG 12)**. Urban green spaces, community gardens and tree-lined streets benefit from pollination through enhanced flowering, seed set and regeneration, which in turn support local biodiversity, air quality and recreational values **(Targets 11.6 and 11.7)**. Studies also indicate that pollination can improve fruit size, shape and shelf-life, thereby reducing food losses along the supply chain and contributing to more sustainable consumption patterns **(Target 12.3)**. Pollinator-based ecotourism and educational initiatives additionally support sustainable lifestyles and awareness of biodiversity values **(Target 12.b)**.

1.45 Pollination has a strong interface with **Climate Action (SDG 13),** and **Life on Land (SDG 15)** through ecosystem-service linkages. Pollination, alongside climate regulation, freshwater and biodiversity, as one of the ecosystem services most closely associated with SDG 13 and SDG 15. Synergies are particularly pronounced between climate action and terrestrial biodiversity, where conserving and restoring pollinator-dependent vegetation enhances carbon sequestration, habitat connectivity and resilience to climate extremes. Conversely, climate-driven changes in temperature and precipitation regimes, together with land-use change and pollution, act as pressures on pollinators and may compromise their capacity to support these goals if not adequately addressed.

Figure 4: Indicative Pollination and SDGs



1.46 Overall, the emerging evidence situates pollination at the core of an integrated SDG agenda. From an environmental-economic accounting perspective, recognising pollination as an ecosystem service that underpins multiple goals provides a rationale for embedding pollinator indicators and pollination-related measures within SDG monitoring frameworks, national biodiversity strategies and sectoral policies. Aligning agricultural, forestry, water, climate and rural-development policies with pollinator conservation can generate co-benefits across food security, poverty reduction, health, climate resilience and biodiversity conservation, thereby advancing the 2030 Agenda in a mutually reinforcing manner.

Chapter- 2
Pollinator of India and their Diversity

Pollinators of India and Their Diversity

2.1 Pollination is a fundamental ecological process that sustains both natural ecosystems and agricultural systems. This keystone ecological function ensures the reproduction of flowering plants, maintains biodiversity, and directly supports food security and human livelihoods. Animal pollination is carried out by a wide variety of insects and vertebrates. Across the broader literature summarized in the provided documents, major pollinator groups include bees, flies, butterflies and moths, wasps, beetles, birds and bats. Each group differs in body size, foraging range, activity period (day or night), and the types of flowers they can effectively service. Approximately 87.5% of flowering plants rely on animals for pollination[5], and insect pollination is indispensable for about 35% of crop production[5],[6].

2.2 As per input provided by ZSI, India exhibits remarkable pollinator diversity and but only constitutes roughly 4 percent of the global bee diversity. Therefore, additional taxonomic research on wild bees of India is needed as a basisi for effective overall research.[7]Beyond bees, India harbors significant populations of bat pollinators, fly pollinators, and various other pollinating organisms that contribute to the maintenance of ecological balance and agricultural productivity. The contribution of different pollinator groups varies in their relative importance, with bees (social and solitary) representing 73 percent of pollinating insects, followed by flies at 19 percent, bats at 6.5 percent, wasps at 5 percent, beetles at 5 percent, birds at 4 percent, and butterflies at 4 percent[8].

2.3 It is important to understand the diversity and distribution of pollinators across India's varied ecological zones as it is essential for ecosystem management, biodiversity conservation, and sustainable agricultural practices. This chapter presents an indicative list of pollinator fauna of India, based on available literature, organized by major pollinator groups including bee pollinators, bat pollinators, fly pollinators, and other significant pollinating organisms.

[5]Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? Oikos, 120(3), 321–326.
https://nsojournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1600-0706.2010.18644.x
[6] Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2006). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences, 274(1608), 303–313.
https://doi.org/10.1098/rspb.2006.3721
[7] [1] Warrit, N., Ascher, J., Basu, P., Belavadi, V., Brockmann, A., Buchori, D., ... & Orr, M. (2023). Opportunities and challenges in Asian bee research and conservation. Biological Conservation, 285, 110173.
[8] PANNURE, A., BELAVADI, V. V., & CARPENTER, J. M. (2016). Taxonomic studies on potter wasps (Hymenoptera: Vespidae: Eumeninae) of south India. Zootaxa, 4171(1), 1.
https://doi.org/10.11646/zootaxa.4171.1.1

Bee Pollinators of India and Their Diversity[9]

2.4 India constitutes roughly 4% of the global bee diversity (~21000 species) with a total of 827 species of bees belonging to 6 families that aid in the pollination of at least 108 food and cash crops[10] and several other species of medicinal plants with cultural significance[11]. Nevertheless, it is likely that the actual number of species present in India is much more than the currently reported number. As most Asian countries, India remain taxonomically understudied with many undescribed bee species. Considering India's biogeographical diversity and high endemism in bee species, the country is expected to host significantly more bee species. Bees as pollinator can be broadly divided into two categories depending on nest building and foraging preferences– free living, that build their own nests and forage pollen and nectar as provision for future generations and cleptoparasites, that do not build nests, instead lay eggs in the nests of free-living species and the larvae feed on the provisions already available in the nests. The free-living bee species includes both social and solitary bees, and are actively involved in pollinating flowers while collecting pollen with their specialised pollen-collecting hairs, known as scopa. Even though all members of the tribes Apini (honeybees) and Meliponini (stingless bees) are considered to be social bees, only two species are domesticated and commercially reared in India, viz. Apis cerana Fabricius and Apis mellifera Linnaeus. On the other hand, cleptoparasitic species lack scopa and do not actively forage for nectar and pollen; hence, their involvement in pollination is usually accidental, similar to other animal pollinators that visit flowers solely to feed on nectar. Conservation efforts for pollinators received early support through the All India Coordinated Research Project (AICRP) on Honeybees, initiated in 1981 by the Indian Council of Agricultural Research. In 2007, this initiative expanded to include the AICRP on Honeybees and Pollinators. Currently, the project encompasses 26 centres across 20 states, most of which are affiliated with state agricultural universities. These centres not only provide training to farmers in sustainable beekeeping but also conduct research on pollination, focusing primarily on honeybees and, to a lesser extent, non-honey bee species.

[9] This section is based on input provided by Zoological Survey of India.

[10] CHAUDHARY, O. P., & CHAND, R. (2017). Economic benefits of animal pollination to Indian agriculture. The Indian Journal of Agricultural Sciences, 87(9).
https://doi.org/10.56093/ijas.v87i9.73903
Rameshkumar, A., Sardar, S., Majumder, B., Dey, S. and Kazmi, S. I. (2022). Observation of bee pollinators (Apoidea) on a medicinal plant, Lippia alba (Mill.) (Verbenaceae). Current Science, 123(5): 703–707. https://doi.org/ 10.18520/cs/v123/i5/703-707
[11]Angmo, S., Sardar, S., Stobdan, T., Chauhan, A., Kazmi, S. I. and Rameshkumar, A. (2024) Megachilid bees (Hymenoptera: Anthophila: Megachilidae) of Ladakh: A morphological and molecular approach. Journal of Asia-Pacific Entomology, 27, 102324. https://doi.org/10.1016/j.aspen.2024.102324

2.5 The Indian bee diversity consists of 695 free living species of bees, belonging to 06 families (Apidae with 205 species within 18 genera, Andrenidae with 39 species within 01 genus, Colletidae with 32 species within 02 genera, Halictidae with 199 species within 25 genera, Megachilidae with 215 species within 20 genera and, Melittidae with 05 species within 02 genera) contributing actively to the pollination of flowers and 132 species of cleptoparasites, belonging to 03 families (Apidae with 55 species within 09 genera, Halictidae with 36 species within 02 genera and, Megachilidae with 41 species within 06 genera) contributing to accidental pollination. This makes Apidae the most speciose family, with 260 species, followed by Megachilidae with 256 species, and Melittidae the least, with only five known Indian species as given in table 1.

Table 1: Diversity of bee pollinators in India compared to global diversity

S.No.	Family	No. of Genera		No. of Species	
		Global	Indian	Global	Indian
1	Andrenidae	62	1	3089	39
2	Apidae	206	25	6184	260
3	Colletidae	120	2	2755	32
4	Halictidae	95	27	4494	235
5	Megachilidae	88	26	4169	256
6	Melittidae	14	2	213	5
7	Stenotritidae	2	0	21	0

Source: Zoological Survey of India

Geographic Distribution of Bee Species

2.6 The distribution of bee pollinators across Indian states and union territories exhibits notable variation both in species composition and species richness. The species composition in the northwestern and trans-Himalayan regions of Himachal Pradesh, Uttarakhand, and the Union Territories of Ladakh and Jammu and Kashmir shows similarity to the Palaearctic fauna. In contrast, the composition in the North-Eastern region shows similarity to the Southeast Asian fauna. The highest diversity of bees is reported from the states of Himachal Pradesh (183 species), followed by Uttarakhand (152 species), Maharashtra (142 species) and Sikkim (122 species) and the Union Territories of Jammu and Kashmir (114 species), Puducherry (38 species) and Ladakh (33 species). In comparison, the least diverse states are Tripura (10 species), Telangana (11 species), Nagaland (12 species) and Mizoram (12 species), and Union Territories are Lakshadweep (09 species), Chandigarh (09 species) and Dadra and Nagar Haveli & Daman and Diu (10 species). The variation depicted in table 2, reflects differences in climate, vegetation types, floral resource availability, and historical patterns of biodiversity research across regions.

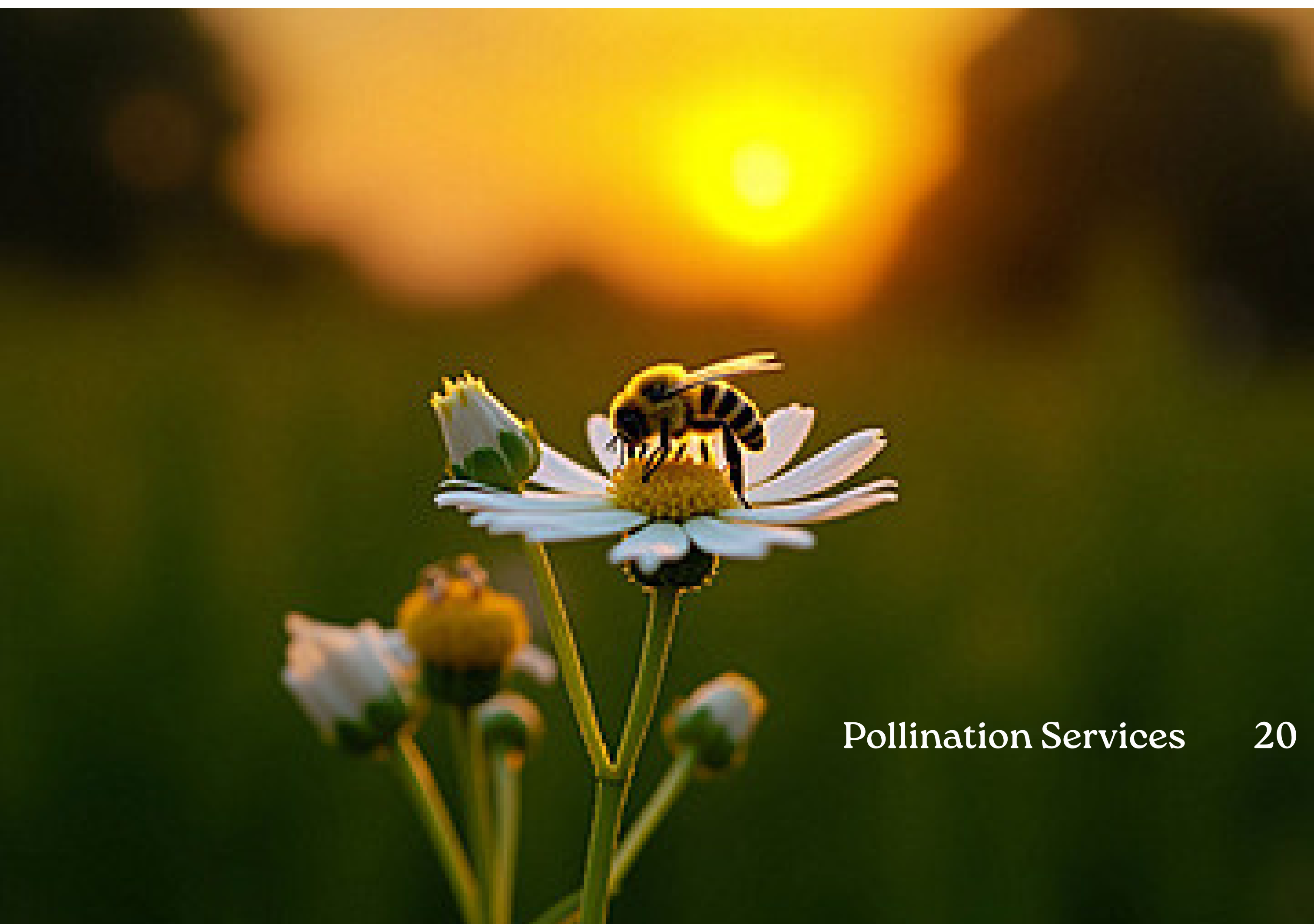


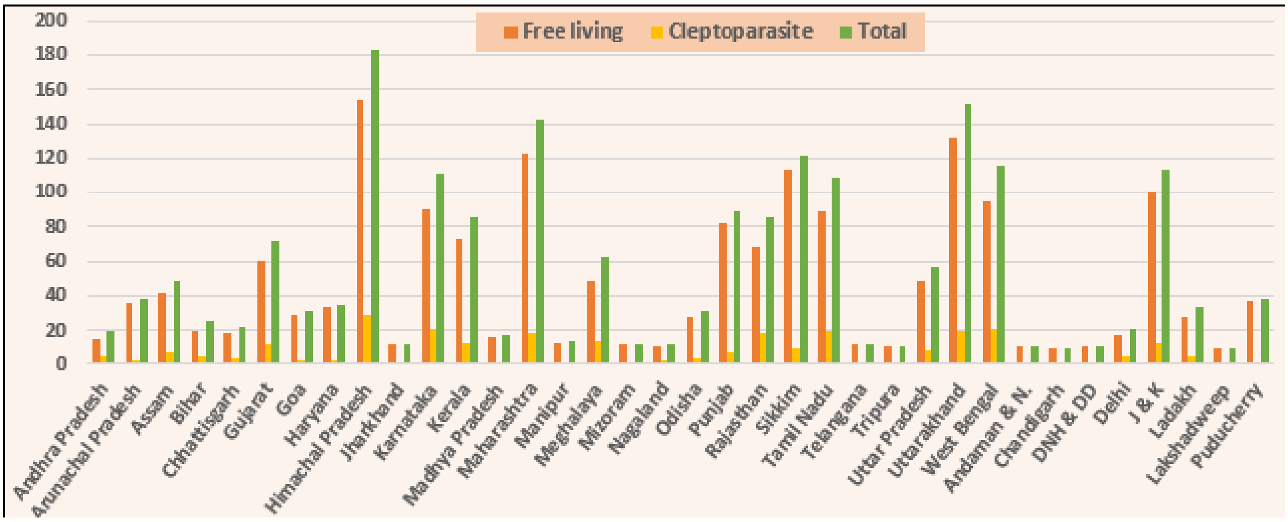
Table 2: State-wise diversity of bee pollinators in India.

States and UTs	Free living	Cleptoparasite	Total
Andhra Pradesh	15	5	**20**
Arunachal Pradesh	36	2	**38**
Assam	42	7	**49**
Bihar	20	5	**25**
Chhattisgarh	19	3	**22**
Gujarat	60	12	**72**
Goa	29	2	**31**
Haryana	33	2	**35**
Himachal Pradesh	154	29	**183**
Jharkhand	12	0	**12**
Karnataka	90	21	**111**
Kerala	73	13	**86**
Madhya Pradesh	16	1	**17**
Maharashtra	123	19	**142**
Manipur	13	1	**14**
Meghalaya	48	14	**62**
Mizoram	11	1	**12**

States and UTs	Free living	Cleptoparasite	Total
Nagaland	10	2	**12**
Odisha	28	3	**31**
Punjab	82	7	**89**
Rajasthan	68	18	**86**
Sikkim	113	9	**122**
Tamil Nadu	89	20	**109**
Telangana	11	0	**11**
Tripura	10	0	**10**
Uttar Pradesh	49	8	**57**
Uttarakhand	132	20	**152**
West Bengal	95	21	**116**
Andaman & Nicobar	10	0	**10**
Chandigarh	9	0	**9**
Dadra Nagar Haveli, Daman & Diu (DNH &DD)	10	0	**10**
Delhi	17	4	**21**
Jammu & Kashmir (J&K)	101	13	**114**
Ladakh	28	5	**33**
Lakshadweep	9	0	**9**
Puducherry	37	1	**38**

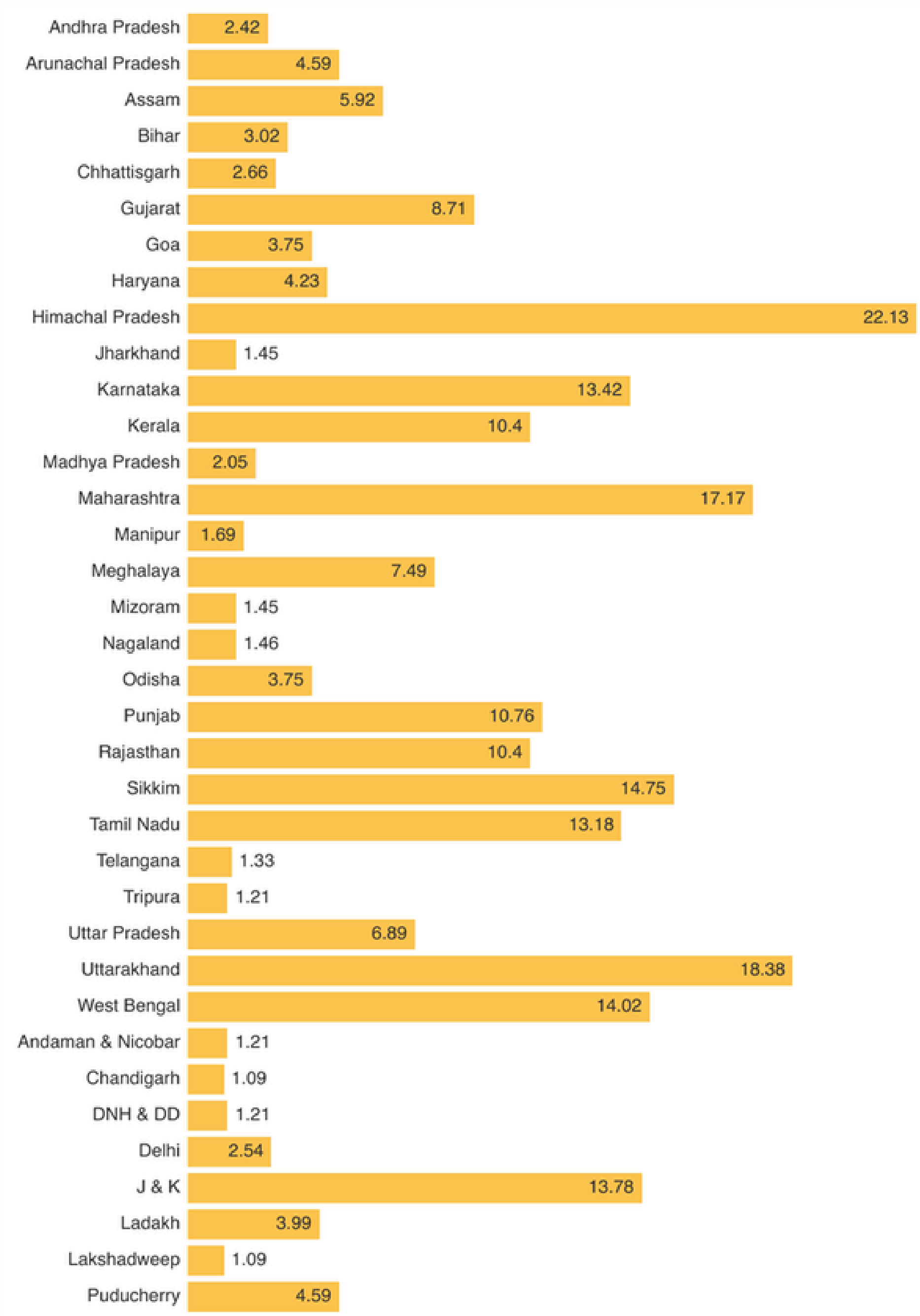
Source: Zoological Survey of India

Figure 5: State-wise diversity of bee pollinators in India.



2.7 Figure 6 illustrates the distribution of bee pollinator diversity across India's states and union territories as a percentage of total bee species. Himachal Pradesh leads with 22.11%, followed by West Bengal (18.38%) and Uttarakhand (17.17%), reflecting higher altitudinal variation, diverse vegetation zones, and greater forest cover in mountainous regions that support rich bee fauna. States like Lakshadweep, Chandigarh, and Tripura show minimal proportions (< 2%), indicating either genuinely lower bee diversity due to limited geographic area and habitat constraints, or insufficient research documentation. The figure demonstrates significant geographic inequality in pollinator distribution, with northern and western mountain states hosting disproportionately higher bee species concentrations compared to plains and island regions.

Figure 6: State-wise proportion of bee pollinators in India



Source: Zoological Survey of India

Bat Pollinators of India and Their Diversity[12]

2.8 Bats represent a vertebrate pollinator group of particular relevance for certain plant species, especially those with low flowering densities, nocturnal flowering and high nectar rewards. These nocturnal and crepuscular mammals possess adaptations for nectar feeding, including elongated snouts, specialized dental structures, and high maneuverability in flight, enabling them to access flowers that are inaccessible to diurnal pollinators. The process of pollination by bats, termed chiropterophily, is particularly important for plants producing large flowers, copious nectar, and pollinating at night or early morning hours[13]. In addition, flower-visiting bats benefit in two major ways: they deposit large amounts of pollen and a variety of pollen genotypes on plant stigmas and act as long-distance pollen dispersers.

2.9 Bats are included among major pollinator groups and are associated particularly with fruit bats in relation to pollination and seed dispersal. The Indian bats diversity consists of 127 species in 40 genera and nine families.

This overall diversity provides the pool from which pollination-relevant guilds (e.g., nectar- and fruit-feeding bats) based on feeding and flower visitation. The fruit bats are responsible for pollination and seed dispersal in a large number of plants, including economically and ecologically significant species. This linkage is especially important for forest regeneration and for maintaining landscape connectivity through mobile vertebrate agent.

2.10 Table 3 presents 8 fruit bat species (family Pteropodidae) that function as effective pollinators of commercial and medicinal plants such as silk cotton, cashew, jackfruit, and mahua in India, all possessing specialized adaptations for nectar and fruit feeding. The listed species range from smaller forms like Lesser Short-nosed Fruit Bat *(Cynopterus brachyotis)* and Greater Short-nosed Fruit Bat *(Cynopterus sphinx),* which are widely distributed across the Indian subcontinent, to the largest Indian bat species, Indian Flying Fox *(Pteropus giganteus*, which plays a prominent role in pollinating large canopy trees. Species such as Greater Long-nosed Fruit Bat *(Macroglossus sobrinus)* possess highly specialized elongated snouts and extended tongues specifically adapted for accessing nectar from deep tubular flowers. These eight species collectively pollinate diverse plant groups including Ficus,

[12This section is prepared based on document cited as:
Saikia, U. (2018). A review of Chiropterological studies and a distributional list of the Bat Fauna of India. **Records of the Zoological Survey of India,** 118(3), 242–280. https://doi.org/10.26515/rzsi/v118/i3/2018/121056

[13] https://www.fao.org/uploads/media/raps_2.pdf

mangoes, and other economically important trees, while performing critical seed dispersal functions in both wild and agricultural ecosystems. Their nocturnal and crepuscular feeding behaviors enable them to pollinate plants producing night-blooming flowers with copious nectar- a pollination niche unavailable to diurnal pollinators. Endemic species like Salim Ali's Fruit Bat *(Latidens salimalii)* restricted to the Western Ghats, and cave-dwelling species like Fulvous Fruit Bat *(Rousettus leschenaulti)*, demonstrate the ecological diversity of bat pollinators across India's varied habitats. These bats are ecologically irreplaceable in maintaining India's tropical forest ecosystem functions through their unique contributions to plant reproduction and forest regeneration.

Table 3: Tentative list of Bat pollinators

S. No	Family	Species	Common Names
1	Pteropodidae	*Cynopterus brachyotis*	Lesser Short-nosed Fruit Bat
2		*Cynopterus sphinx*	Greater Short-nosed Fruit Bat
3		*Latidens salimalii*	Salim Ali's Fruit Bat
4		*Macroglossus sobrinus*	Greater Long-nosed Fruit Bat
5		*Megaerops niphanae*	Ratanaworabhan's Fruit Bat
6		*Pteropus giganteus*	Indian Flying Fox
7		*Rousettus leschenaulti*	fulvous fruit bat
8		*Sphaerias blanfordi*	Blanford's Fruit Bat

Source: Saikia, U. (2018). A review of Chiropterological studies and a distributional list of the Bat Fauna of India. Records of the Zoological Survey of India, 118(3), 242–280

2.11 Fruit bats are responsible for pollination and seed dispersal of many economically and ecologically significant plants. The relationship between bats and flowering plants represents co-evolutionary adaptations spanning millions of years. Plants producing bat-pollinated flowers typically exhibit characteristics such as large flower size, night-time flowering, pale coloration for visibility in low light, and copious nectar production. In Indian tropical forests, bat pollination ensures reproductive success of numerous canopy and sub-canopy tree species that provide critical ecosystem services including carbon sequestration, watershed protection, and habitat provision for other species.

Fly pollinators of India and their diversity[14][15][16]

2.12 Flies (Order Diptera) represent the second most important group of pollinators globally and in India. The diversity of flower-visiting flies in India consists of 116 dipteran species belonging to 16 families acting as pollinators. Flies possess physical and behavioral traits that make them particularly effective pollinators under certain environmental conditions. Unlike bees, flies can pollinate effectively in cloudy weather, high wind speeds, and other conditions that restrict bee foraging activity. The majority of fly species are present in fields throughout the year, unlike strictly seasonal bees, providing continuous pollination services. Furthermore, many fly species are generalist foragers, visiting diverse plant species and transferring pollen across floral variations. Flies have been recognized as important pollinators of diverse crop species including vegetables (cauliflower, carrot, onion), oilseeds (rapeseed), fruits (apple), and medicinal plants. In tropical areas, flies serve as primary pollinators of economically important crops such as cacao, mango, cashew, and tea.

2.13 Table 4 presents 16 dipteran families documented as flower-visiting pollinators in India, comprising a total of 116 species with highly unequal distribution across families. Syrphidae (hover flies) dominates with 45 species constituting 38.46% of total dipteran pollinators, making it by far the most important fly pollinator group in Indian ecosystems due to their exceptional hovering ability, year-round availability, and effectiveness in pollinating diverse crop species including vegetables, oilseeds, and fruits.

This section is prepared based on documents cited as:

[14] Mitra, B., Parul, P., Banerjee, D., & Ghosh, A. (2005). Studies on the Dipteran Pollinators of Medicinal Plants in India. **Records of the Zoological Survey of India**, 104(3-4), 23–29.
https://doi.org/10.26515/rzsi/v104/i3-4/2005/159298

[15] Mitra, B., & Banerjee, D. (2007). Fly Pollinators: Assessing their Value in Biodiversity Conservation and Food Security in India. Records of the Zoological Survey of India, 107(1), 33–48.
https://doi.org/10.26515/rzsi/v107/i1/2007/159161

[16] Mitra, B. (2010). Diversity of Flower-Visiting Flies (Insecta : Diptera) in India and their Role in Pollination. Records of the Zoological Survey of India, 110(2), 95–107.
. https://doi.org/10.26515/rzsi/v110/i2/2010/158952

The second and third most significant families are Bombyliidae (bee flies) with 18 species (15.38%) possessing long sucking mouthparts specialized for tubular flowers, and Muscidae (house-flies) with 17 species (14.53%) that pollinate cruciferous and umbelliferous crops. Calliphoridae (blowflies) with 12 species (10.26%) represent important secondary pollinators of vegetables, while Sepsidae and Stratiomyidae each contribute 4 species (3.42%) representing soldier flies and scavenger flies with specialized ecological roles. The remaining 10 families contribute minimally with 1-3 species each (0.85-2.56%), including Ceratopogonidae (biting midges), Culicidae (mosquitoes), Drosophilidae (fruit flies), Oestridae (bot flies), Tabanidae (horse flies), Tachinidae, Tephritidae, and others. This distribution pattern demonstrates that fly pollination services in India are concentrated within just three families (Syrphidae, Bombyliidae, and Muscidae) accounting for 68.37% of total dipteran pollinator diversity, while the remaining 13 families play supporting roles in specialized pollination niches.

Table 4: Tentative list of diversity of fly pollinators in India

S. No.	Family	Total Number of Species	% Share
1	Syrphidae	45	38.46%
2	Bombyliidae	18	15.38%
3	Muscidae	17	14.53%
4	Calliphoridae	12	10.26%
5	Sepsidae	4	3.42%
6	Stratiomyidae	4	3.42%
7	Tachinidae	3	2.56%
8	Tephritidae	3	2.56%

S. No.	Family	Total Number of Species	% Share
9	Ceratopogonidae	2	1.71%
10	Sarcophagidae	2	1.71%
11	Tabanidae	2	1.71%
12	Culicidae	1	0.85%
13	Diopsidae	1	0.85%
14	Drosophilidae	1	0.85%
15	Oestridae	1	0.85%
16	Ulididae	1	0.85%
	Total	**116**	**100%**

Source: Mitra, B. (2010). Diversity of Flower-Visiting Flies (Insecta : Diptera) in India and their Role in Pollination. Records of the Zoological Survey of India, 110(2), 95–107.

Other Pollinators[17][18]

2.14 Beyond bees, bats, and flies, India harbors diverse pollinator fauna including wasps, beetles, butterflies, moths, birds, and other invertebrates that contribute to ecosystem pollination services.

Wasps as Pollinators

2.15 Wasps represent a significant but understudied pollinator group. While most wasps are predatory or parasitic, certain species interact with flowers and function as incidental pollinators. Specialized pollination relationships have evolved between orchids and parasitic wasps, including the sexually-deceptive orchid systems found in specialized flora. Although quantitative data on wasp pollination in India remains limited, studies from other regions indicate that wasps can be effective pollinators of specific plant groups, particularly in specialized ecological systems.

[17] https://openknowledge.fao.org/server/api/core/bitstreams/4fc56a22-2e2d-4f6f-b63d-4ab35c274691/content
[18] https://www.fao.org/uploads/media/raps_2.pdf

Fig pollinators (Hymenoptera: Agaonidae)

2.16 There are 750 documented species of Ficus, commonly known as fig trees, found worldwide. Among these, 89 species thrive in India's diverse ecosystems. Ficus trees are particularly famous for their fascinating and complex relationships with specific insect pollinators, demonstrating a unique form of mutualism that varies among species. The pollinators belong to the family Agaonidae (Hymenoptera: Chalcidoidea) and play a crucial role in the life cycle of Ficus trees. This family includes 28 distinct species across four genera. In India, approximately 25 species of Ficus have been identified as host plants for these important pollinators.

Beetles as Pollinators

2.17 Beetles are considered among the most important pollinating insects of flowering plants, with estimates of more than 77,000 beetle species visiting flowers globally. Beetles play particularly significant roles in pollinating plants of the Annonaceae family, with over 90 percent of species in this family relying on beetle pollination. The oil-palm pollination system also demonstrates the prominence of beetles as specialized pollinators. Species of beetles belonging to families such as Curculionoidea, Cleroidea, Cucujoidea, and Tenebrionoidea are important pollinators of various plant groups.

Butterflies and Moths as Pollinators

2.18 Lepidoptera, comprising butterflies and moths, represents a highly diverse order with approximately 140,000 species globally possessing floral-visiting capabilities. While butterflies have received greater research attention than moths, both groups contribute significantly to pollination services. Butterflies are particularly important pollinators of colorful flowers, serving as indicators of ecosystem health and biodiversity in Indian landscapes. Moths, being predominantly nocturnal, pollinate specialized plants with night-flowering characteristics.

Birds as Pollinators

2.19 Various bird species in India function as pollinators of specialized flowering plants. Sunbirds and other nectarivorous birds visit flowers for nectar, incidentally transferring pollen among plants. Hummingbirds, while not native to India, represent analogous pollinators in tropical systems. Birds are particularly important pollinators of red and tubular flowers adapted for avian visitation. In India, birds from the families Nectariniidae, Sturnidae, and Zosteropidae are the primary pollinators, with approximately 58 species known to contribute to the pollination. It is reported that 292 species of forest birds are involved in pollination and seed dispersal in South India[19].

Other Pollinating Organisms

2.20 Vertebrate pollinators beyond bats include non-flying mammals such as primates, rodents, and other tree-dwelling species that visit flowers for nectar and pollen. Although less quantitatively studied than insect pollinators, these species contribute to pollination of specialized plant systems in forested ecosystems. Reptiles, particularly some lizard species in tropical regions, have been documented as occasional flower visitors.

[19] Balasubramanian, P. (2012). Pollination and seed dispersal services by Indian forest birds. In Ecosystem services: Do we need birds? (BOU Proceedings). British Ornithologists' Union. http://www.bou.org.uk/bouproc-net/ecosystem-services/balasubramanian.pdf

Chapter- 3
Pollination Services in SEEA Framework: Concepts and Overview

SEEA Ecosystem Accounting and Pollination[20]

3.1 In 2021, the System of Environmental Economic Accounting – Ecosystem Accounting (SEEA EA) was adopted as an international statistical standard by the United Nations Statistical Commission. This marked an important step towards integrating information on ecosystems into the broader system of national accounts. Ecosystem accounts provide an organised framework to record how ecosystems contribute to economic activity and to human well-being, and how these contributions are affected by changes in ecosystem extent and condition over time.

3.2 Ecosystem accounting describes the biophysical environment in terms of "ecosystem assets". These are spatial areas, such as forests, croplands, wetlands or urban green spaces, that are relatively well defined and specific in terms of ecosystem type and condition. For each ecosystem asset, the SEEA EA envisages a sequence of accounts. Extent accounts capture the area of different ecosystem types. Condition accounts describe the quality or health of those ecosystems. Asset accounts track changes in the stock of ecosystem assets over time. Finally, ecosystem services accounts record the flows of services from ecosystems to different economic sectors and households.

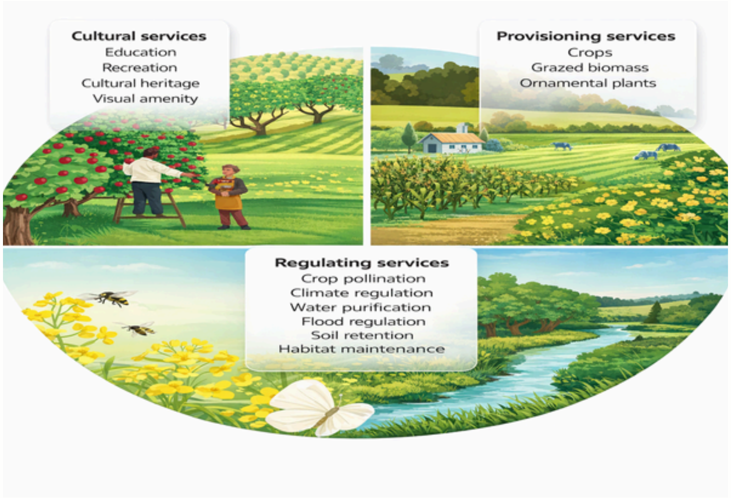
3.3 Within the SEEA EA, ecosystem services are defined as the contributions of ecosystems and their biodiversity to human well being eg the benefits from them-used in economic and other human activity. The framework recognises three broad groups of services: (1) provisioning services, (2) regulating and maintenance services, and (3) cultural services. Provisioning services are the material outputs from ecosystems, such as crops, timber, fish or freshwater, that enter production and consumption. Regulating services refer to the biophysical processes by which ecosystems regulate environmental conditions, including climate regulation, water purification, soil formation, pest control and pollination whereas maintenance services are those that help sustain the rest of the services e.g. nutrient cycling. Cultural services cover non-material benefits, such as recreation, aesthetic appreciation, spiritual value and heritage.

3.4 In Figure 7, Provisioning services generally correspond to products that are mostly recognized as goods in standard economic production and accounting systems. For these, ecosystem accounting isolates the specific contribution of ecosystems (for example, the role of soil

[20]This section has been adapted from the System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA), as provided in the official United Nations document (United Nations et al., 2024). The structure, definitions, and substantial portions of the explanatory content have been directly drawn from this authoritative source, with select modifications to contextualize the material for specific applications . For the original framework and comprehensive methodological guidance, please refer to
https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_f124_web_12dec24.pdf

fertility, water availability or pollination in crop production). Regulating and maintenance services, in contrast, are not usually recorded explicitly in the SNA, even though they underpin production and well-being. Cultural services are likewise mostly absent from conventional economic statistics, although their importance in sustaining community identity and quality of life is widely recognized.

Figure 7: Depiction of ecosystem service categories[21]



3.5 The primary objective of ecosystem service accounting is to quantify the flows of services from ecosystem assets to different groups of beneficiaries. Final ecosystem services are those that are directly used by economic units or households, such as harvested crops or nature-based recreation. Intermediate ecosystem services are those that support other ecosystem services, for instance, habitat services that maintain pollinator populations, which in turn support crop pollination as a final service. In many cases, the same ecological process can be treated as either intermediate or final, depending on the accounting boundary and the way services are defined.

3.6 By recording the supply of ecosystem services by ecosystem type and the use of these services by industries and households, SEEA EA compiles “supply and use tables” for ecosystem services. On the supply side, the tables show how much of each service is generated by each ecosystem type, in physical and, where possible, monetary terms. On the use side, they show which sectors (such as agriculture, manufacturing, services, or households) benefit from each service and in what quantity. The accounting structure thus parallels the familiar SNA supply–use tables, but with ecosystem services treated explicitly as flows from ecosystem assets to the economy.

[21] https://publications.gc.ca/collections/collection_2023/statcan/16-001-m/16-001-m2023001-eng.pdf

Pollination as Ecosystem Services

3.7 In SEEA-EA framework, Pollination services are the ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. This may be recorded as a final or intermediate service.

3.8 Various classifications and typologies of Ecosystem Services have been put forward including the Millennium Ecosystem Assessment, the TEEB ES typology, the Common International Classification of Ecosystem Services (CICES), the National Ecosystem Service Classification System (NESCS Plus), and more recently Nature's Contributions to People (NCP) – as proposed by the IPBES has defined Pollination Services. Based on these existing schemes, the pollination services has been defined in table 5.

Table 5: Definition of Pollination services based on various classifications and typologies[22]

SEEA	Pollination services
SEEA (Subtypes)	
SEEA Code	2.17
SEEA Description	Pollination services are the ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. This may be recorded as a final or intermediate service.
CICES (v5.1) Class	Pollination (or 'gamete' dispersal in a marine context)
CICES Code	2.2.2.1
NESCS	(if pollination as crop input) Fauna OR Atmosphere-Support of Plant Cultivation (gamete dispersal is an ecosystem process preceding a final ES)

[22] https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_online_supplement_ecosystem_services_reference_list_crosswalk.xlsx

NESCS Code (WWW.XXX.YYY.ZZZ) {WWW: Environmental classes; XXX: Ecological end-product classes; YYY: Direct use classes; ZZZ: Direct user classes}	**2WW.(1/5).108.(111/161/211/399)**
IPBES	Pollination and dispersal of seeds and other propagules
IPBES Reporting Categories of Nature's Contribution to People	2
MA	Pollination
TEEB	Pollination

3.9 These classification links are important for harmonising assessments across studies and for ensuring that pollination accounts compiled under SEEA EA are compatible with other global initiatives. By anchoring pollination in the regulating and maintenance service domain, the framework highlights that its primary contribution is not a material output but a biological process that enables other benefits such as crop production, maintenance of wild plant populations and associated cultural values. This also helps avoid double counting: where crop provisioning is recorded as a final service, the portion of crop output attributable to pollination must be excluded from that account if pollination itself is treated as a separate final service.

3.10 Conceptually, allocating the supply of pollination to specific ecosystem types is challenging because pollinators rely on a mosaic of habitats. Bees and other pollinating insects typically utilise cropland, semi-natural grasslands, forest edges, hedgerows and other habitat patches for nesting and foraging. Agroecosystems are the major beneficiaries of pollination services, yet they also provide habitat and floral resources that contribute to service supply. One practical solution used in experimental accounts has been to treat cropland as the supplier of the final pollination service (because the benefit - crop yield - is realised there), while surrounding natural and semi-natural ecosystems are recognised as supplying an intermediate habitat service that supports pollinator populations.

Treatment of Pollination Services in Ecosystem Accounting

3.11 In measuring ecosystem services such as pollination services associated with crops and wood, it is most common to measure the biomass that is cultivated. The estimated ecosystem contribution (or share) should vary depending on the production context but, if this is not possible, a proxy measure may be used based on the gross biomass harvested. A second way to assess ecosystem contributions is to measure individual ecosystem services-such as pollination, soil formation, or water regulation-that together support the overall growth of biomass. Instead of counting the crops produced as an ecosystem service in themselves, this approach views the harvested biomass as the final outcome of many underlying ecological processes. In this framework, services like pollination are classified as intermediate ecosystem services because they help enable crop growth but are not the final product. The final ecosystem service is the biomass that is ultimately harvested and used.

3.12 Although there is a diversity of cultivated production contexts, the conceptual intent for ecosystem accounting remains consistent, that is, measuring the ecosystem contribution, while accepting that in different production contexts the relative contribution of ecosystems will vary. The measurement of the ecosystem contribution in different contexts can be considered in two distinct ways. One approach uses the biomass harvested as the measurement focus for identifying the overall ecosystem contribution and the other focuses on the various types of ecosystem contributions such as those involving pollination, which will be used in different combinations in different contexts as depicted in table 6.

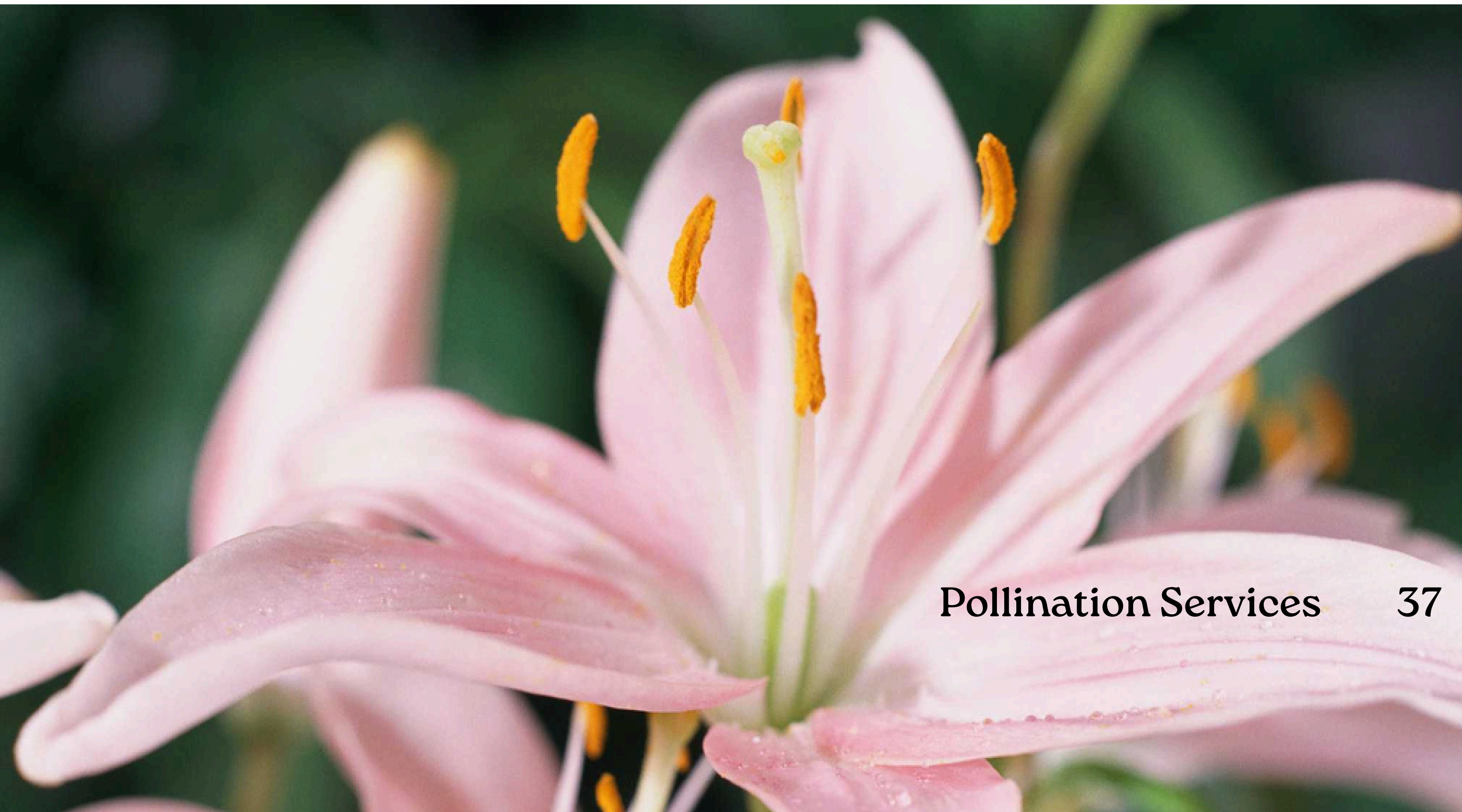


Table 6: Framework for Pollination Service[23]

Ecosystem service		Crop provisioning services	Pollination services
Common ecosystem types		Cropland	Many ecosystem types, mainly near cropland areas, but also urban gardens
Factors determining supply	Ecological	Soil fertility, especially chemical state (e.g. soil organic carbon, nutrients); climate; water supply; **pollination**; genetics	Abundance and location of wild pollinators
	Societal	Farm management at different stages of production process; harvesting practices; air pollution affecting soil quality	Ecosystem management
Factors determining use	Demand for biomass (e.g. for food)	Location of crops benefiting from wild pollination	
Potential physical metrics for the ecosystem services	Gross tons of cultivated plants	Area of crops pollinated, by type of crop	
Benefits	Crop products	Reduced need for alternative forms of pollination, including paid pollinator services (SNA benefit)	
Main users and beneficiaries	Agricultural producers, including household and subsistence production	Cropland ecosystems, ultimately agricultural production household and subsistence production; households	

[23] https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_f124_web_12dec24.pdf

Recording Pollination services

3.13 Where there is a sequence of intermediate ecosystem services and final ecosystem services, recording the supply and use of each service ensures that the appropriate net effect is shown. Using an example involving the ecosystem services of pollination and biomass provisioning, the supply of pollination services by one for use in another ecosystem is recorded as supply and use of an intermediate service depicted in table 7. In the SEEA EA framework, a Physical Supply and Use Table (PSUT) is an accounting table that records ecosystem service flows in physical units, showing the supply of ecosystem services by ecosystem assets/ecosystem types (e.g., forests, cropland, grasslands) and the corresponding use of those services by economic units/beneficiaries (e.g., industries, households and government).

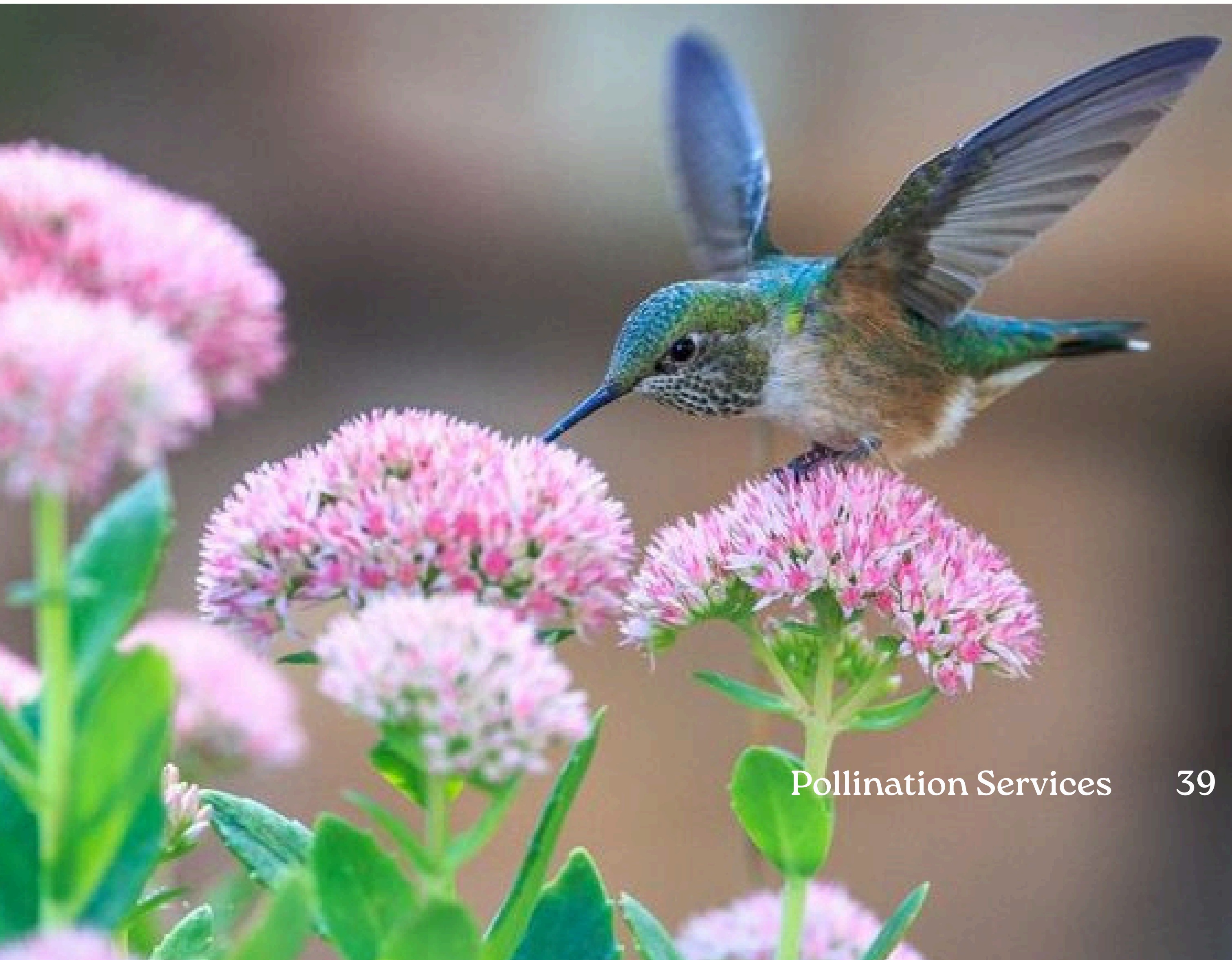


Table 7a: Sample Basic ecosystem services- Physical Supply Table

SUPPLY	Ecosystem services (reference list)		ES: Biomass provisioning services	IS: Pollination services
	Measurement unit		Tons	Number of visits [a]
Economic units	Industries	Agriculture		
		…….		
		Other industries		
	Total Industry			
	Government consumption			
	Household consumption			
	Total supply by resident economic units			
	Supply by non-resident economic units – Imports			
Total supply by economic units				
Ecosystem type	Terrestrial	Forest	-	-
		Croplands	80	-
		Grasslands	-	2000
	Freshwater		-	-
	Marine		-	-
Total supply by resident ecosystem assets			-	-
Supply from non-resident ecosystem assets – Imports			-	-
Total supply by ecosystem assets			-	-
TOTAL SUPPLY			80	2000

Table 7b: Sample Basic ecosystem services- Physical Use Table

USE	Ecosystem services (reference list)		ES: Biomass provisioning services	IS: Pollination services
	Measurement unit		Tons	Number of visits [a]
Economic units	Industries	Agriculture	80	-
		…….	-	-
		Other industries		-
	Total Industry		80	-
	Government consumption		-	-
	Household consumption		-	-
	Total use by resident economic units		-	-
	Exports – Final Ecosystem Services		-	-
Total use by economic units			80	-
Ecosystem type	Terrestrial	Forest		
		Croplands		2000
		Grasslands		
	Freshwater		-	-
	Marine		-	-
Total use by resident ecosystem assets			-	-
Exports – intermediate services			-	-
Total use by ecosystem assets			-	-
TOTAL USE			80	2000

Abbreviations: ES, final ecosystem service; IS, intermediate ecosystem service;
Note: A grey cell signifies "not applicable". The data provided are only for illustrative purpose.
[a] Number of pollinator visits is one potential measure of the quantity of pollination services. Other metrics may be used.

3.14 By ensuring that a sequence of supply and use entries are recorded for each type of ecosystem service, the overall contribution of each ecosystem can be determined. For example, through consideration of the column for cropland, the output of biomass provisioning services can be seen to require the input of pollination services from grassland ecosystems. It is to be noted, however, that no aggregation across rows should be undertaken given that the entries reflect the use of different measurement units. Further, it should be noted that there is no double counting implied through the recording of intermediate services since the user of the intermediate service is different from the user of the associated final ecosystem service. It is to be noted that the SUT format is designed for recording multiple connections. However, before the entries are made, the logic of those connections needs to be well understood and to reflect a coherent and robust description of the relationship between ecosystems and human activity in biophysical terms.

Determining pollination services measurement baselines

3.15 Entries in the ecosystem services flow accounts reflect a total flow over an accounting period, for example, total fish caught from marine areas during a year or total number of plants pollinated. To ensure that all accounting entries in the ecosystem services flow accounts refer to a total flow and can be compared across different contexts, ecosystem services measurement baselines are used.

3.16 The identification of regulating and maintenance services entails a focus on the extent to which ecological processes contribute to environmental conditions that are beneficial to people and their activities. In these cases, the implicit measurement baseline is zero (i.e. in the case of pollination, there is no transfer of pollen) given in table 8.

Table 8: Baselines for Pollination services

Type of service	Baseline
Pollination services	No/zero pollination

Monetary valuation of Pollination services

3.17 Using a reference to the current production boundary of the SNA, two valuation contexts can be distinguished. First, in some cases, flows of ecosystem services are inputs to the production of goods and services within the SNA production boundary, i.e. SNA benefits. In these cases, the values of ecosystem services are implicitly embodied within values of goods and services recorded in the national accounts. Examples include ecosystem services that contribute to agricultural output, such as crop pollination. Monetary valuation therefore involves partitioning the values of the goods and services recorded in the national accounts to reveal the ecosystem contribution. In these contexts, the ecosystem contribution may encompass both final ecosystem services and intermediate services, while it is recognized that the values of intermediate services will themselves be embodied in the value of the associated final ecosystem service. The ecosystem service is then recorded as an output of the ecosystem asset and an input of the economic unit that uses the ecosystem service. In a system-wide context, value added is unaffected by the recording of this transaction, but both total outputs and total inputs are increased.

3.18 Second, in other cases, ecosystem services contribute to benefits received by economic units, including households and governments that are not within the SNA production boundary, i.e. non-SNA benefits. For example, pollination for forests regeneration contribute to cleaner air whose value is not included in national accounts measures of output. In this case, estimating the accounting entries based on exchange values requires (a) determining the prices that would be charged on behalf of the ecosystem asset for the ecosystem services if a market existed; (b) estimating the costs of obtaining an ecosystem service that would need to be incurred by an economic unit to secure the benefits; or (c) assessing the loss of benefits to an economic unit that would be incurred if ecosystem services were lost.

Technique

3.19 The valuation methods have been developed in the context of valuing final ecosystem services, that is, with a focus on the contribution of ecosystems to economic and human activity. Where intermediate services are recorded, the same valuation methods can be applied since the intent remains to measure the contribution of the ecosystem to economic and human activity. For example, where flows of pollination services are recorded as inputs to biomass provisioning services, both of these types of services can be valued in terms of their contribution to the associated agricultural output.

3.20 *Productivity change method:* In this method, the ecosystem service is considered an input in the production function of a marketed good. Thus, changes in the service will lead to changes in the output of the marketed good, holding other things equal. The value of the service is derived in three stages. First, the marginal product (contribution) of the ecosystem service is estimated as the change in the value of production consequent upon a marginal change in the supply of the ecosystem service. Second, the marginal product is multiplied by the price of the marketed good to derive a marginal value product for the ecosystem services. Third, this marginal value product is multiplied by the physical quantity of the provided ecosystem service to obtain the value of the ecosystem service. The relationships should be estimated for a single accounting period, recognizing that they may change over time.

3.21 The productivity change method has been used to price the services provided by water and other inputs in agriculture, for example, pollination, across locations where detailed data are available to estimate production functions.

Tools for Pollination Services Accounting - Valuation[24]

3.22 Direct observation and measurement of pollination services at large spatial scales are challenging. Field experiments and plot-level studies can provide detailed information on pollinator behaviour and yield responses, but they are resource-intensive and difficult to generalise. For national-scale ecosystem accounting, spatially explicit models are therefore needed to estimate indicators of pollination potential and to link these indicators to crop distribution and production statistics.

3.23 Several modelling tools have been developed that can provide inputs compatible with SEEA EA supply and use tables for pollination services. Among these, the Ecosystem Service Mapping Tool (ESTIMAP), the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) crop pollination model, and the Artificial Intelligence for Environment and Sustainability (ARIES) for SEEA Explorer are particularly relevant. These tools can generate indicators of pollination potential, indices of pollinator abundance, or spatially disaggregated

[24] https://seea.un.org/ecosystem-accounting/biophysical-modelling

estimates of pollination value, which can then be aligned with the logic chain and PSUT structure described above.

Ecosystem Service Mapping Tool (ESTIMAP)[25]

3.24 The Ecosystem Service Mapping Tool (ESTIMAP) has been applied in the European Union to develop experimental accounts for crop pollination, treating pollination as a regulating service defined as the fertilisation of crops by insects and other animals that maintains or increases crop production. ESTIMAP responds to this policy need by modelling the spatial distribution of pollination potential and linking it to the distribution of pollinator-dependent crops.

3.25 The ESTIMAP crop pollination methodology distinguishes three main components: (a) pollination potential, representing the ecosystem's capacity to support wild insect pollinators; (b) demand for pollination, defined as the extent of pollinator-dependent crops; and (c) the actual flow of crop pollination, derived from the spatial overlap between potential and demand. Pollination potential is assessed as an indicator of environmental suitability for pollinators and is used to delineate service-providing areas (SPAs) with high, medium, low or no pollination potential.

3.26 To estimate pollination potential, ESTIMAP combines two complementary models: an expert-based model for solitary bees, which evaluates the capacity of the environment to provide food and nesting resources, and a species distribution model for bumblebees based on species occurrence records. Both models depend on land cover, climate variables and distance to semi-natural areas, and together they generate a suitability score for each pixel. The pixel-wise average of the two models is used as an indicator of pollination potential, with declines in the score signalling reduced ecosystem potential to supply pollination services. Demand for pollination is quantified as the area of pollinator-dependent crops, derived from agricultural models such as CAPRI and distinguished by dependency levels (e.g., highly dependent fruits versus low-dependence crops such as pulses or tomatoes). The actual flow is then calculated by identifying areas where pollinator-dependent crops overlap SPAs with medium or high pollination potential; areas with low or no potential indicate unmet demand and highlight regions where crop production is not fully benefiting from pollination.

[25] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC87585/lb-na-26474-en-n.pdf

3.27 ESTIMAP links these biophysical outputs to monetary valuation and accounting tables. The method uses agricultural economic accounts (e.g., ESTAT data on economic accounts for agriculture) and disentangles the portion of crop production attributable to pollination, distinguishing the pollinated share of pollinator-dependent crops from the total. The resulting estimate of the actual flow of crop pollination, in physical (tonnes) and monetary terms, is then integrated into SEEA-style supply and use tables, with cropland ecosystems as suppliers and agricultural crop groups (such as fresh fruits or oilseeds) as users. Beyond accounting, ESTIMAP outputs have clear policy applications. Spatial maps of pollination potential, unmet demand and service flows can identify priority areas for ecosystem restoration, green infrastructure deployment and reduction of pesticide use.

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) crop pollination model[26]

3.28 The InVEST crop pollination model focuses on wild bees as the principal animal pollinators in many agricultural systems. It represents pollinator supply as a function of two key resources: nesting substrates and floral resources, both derived from land-use/land-cover (LULC) maps and associated biophysical attributes. For each pollinator guild or species, users specify nesting preferences, seasonal activity and typical foraging distances. The model then computes an index of pollinator supply at each pixel, taking into account nesting suitability and the accessibility of floral resources in surrounding cells within the foraging range.

3.29 On this basis, InVEST estimates the abundance of pollinators visiting each pixel, including crop fields, and can produce spatial layers for pollinator abundance and visitation. When farm boundaries, crop types, pollination dependence and information on managed pollinators are provided, the model also computes indices of pollination-dependent yield and the contributions of wild versus managed pollinators. Total yield is expressed as a function of the crop's dependence on pollination and the degree to which pollination needs are met, with the proportion of pollinator-dependent yield attributable to wild pollinators derived as a residual after accounting for managed pollinators.

3.30 The InVEST pollination model is intentionally index-based, reflecting limited data on absolute nest densities, resource availability and crop-specific yield functions. While this constrains the estimation of absolute economic values, the model is well suited to explore

[26] https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/en/croppollination.html

relative changes in pollination services under alternative land-use or management scenarios. For SEEA EA applications, InVEST outputs can be summarised by ecosystem type and linked to crop production statistics, supporting the compilation of physical supply tables (e.g., indices of pollination potential or pollinator abundance by ecosystem) and informing productivity-based valuation of pollination services.

Artificial Intelligence for Environment and Sustainability (ARIES) for SEEA Explorer[27]

3.31 ARIES (Artificial Intelligence for Environment and Sustainability) represents a different generation of modelling tools, designed as an integrated, AI-enabled platform rather than a single model. It uses reasoning algorithms, decision rules and a semantic framework to connect diverse data and models, automatically selecting the "most appropriate" combination for a user's query. ARIES emphasizes FAIR principles-findable, accessible, interoperable and reusable-by providing open-source software and an online library of models and data that can be composed dynamically.

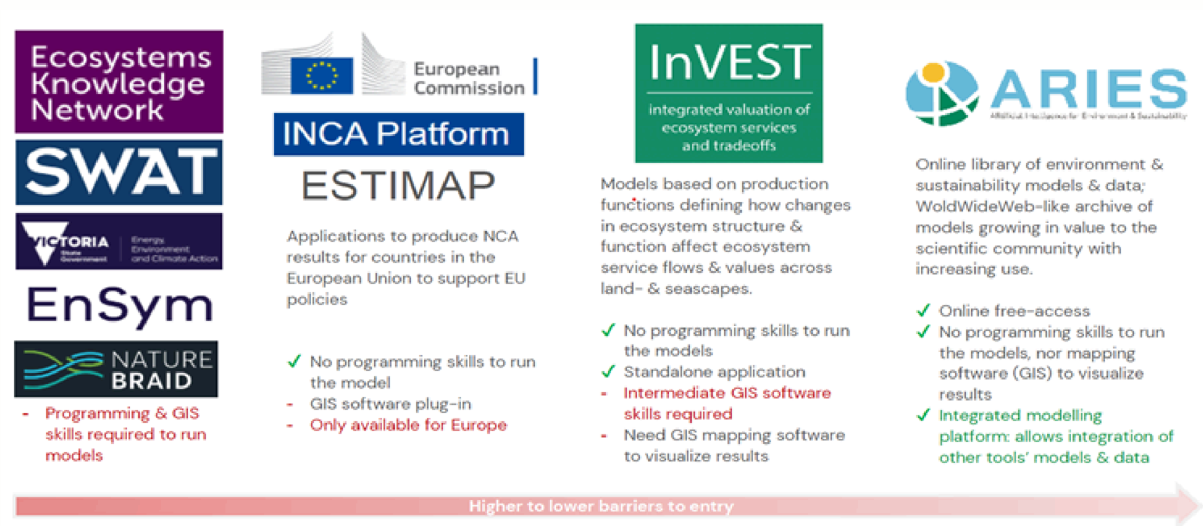
3.32 The ARIES for SEEA Explorer is an application built on this platform specifically to compile ecosystem accounts conformant with SEEA EA. It uses global remote-sensing data and models to generate a basic set of ecosystem accounts for any user-defined terrestrial area, such as a country, watershed or administrative unit. The tool runs entirely through a web browser, requiring no programming skills, and produces tables and maps for ecosystem extent, selected ecosystem services and related indicators, accompanied by detailed documentation of data sources, coefficients and modelling steps.

3.33 ARIES for SEEA is particularly relevant for countries with limited data and technical capacity, allowing them to generate first-cut ecosystem accounts using globally consistent datasets, while also enabling more advanced users to integrate national data and models. Within the broader ARIES framework, pollination is modelled through workflows that represent pollinator occurrence, insect activity, pollinated yield and the net value of pollination, visualised as data-flow diagrams. These workflows can be customised to local conditions and combined with national agricultural statistics, making ARIES a flexible platform for generating SEEA-compatible pollination accounts.

[27] https://seea.un.org/content/aries-for-seea

3.34 Figure 8 highlight the different strengths of each tool, the data requirements, the scales at which they operate, and the types of outputs they generate, thereby guiding countries in selecting appropriate approaches for developing pollination accounts.

Figure 8: Tools available for Natural Capital Accounting compilation[28]



3.35 Table 9 shows pros, cons and its applicability in India. Across ESTIMAP, InVEST and ARIES, the main barriers to calculating pollination services in India arise from both tool-design limitations and India-specific evidence gaps. ESTIMAP is configured to support EU accounting workflows, so applying it to Indian pollination contexts typically requires substantial re-parameterisation and institutional adaptation, and its multi-language implementations create practical deployment constraints for routine account production. InVEST and ARIES face a common accounting challenge: both have limited/unfinished treatment of beneficiaries and ecosystem service use, making it difficult to translate biophysical pollination outputs into SEEA-style service use attribution (i.e., linking benefits clearly to crop producers, households, or enterprises). These constraints are amplified in India by limited baseline information and monitoring for pollinators and crop-specific dependency parameters-pollination dependency of many crop varieties and consistent field evidence needed for calibration/validation are often lacking-so model outputs can remain uncertain even when tools are technically available.

[28] https://seea.un.org/sites/seea.un.org/files/day_3-_introduction_to_aries_for_seea.pdf

Table 9: Overview of biophysical modelling approaches used in ecosystem accounting[29]

Biophysical modelling approach	**Pros**	**Cons**	**India Context Applicability**
ESTIMAP	Endorsed by Joint Research Centre to underpin ecosystem accounting in the European Union Model customizability is possible.	Models are written in different programming languages, so are difficult for external users to apply	Limited Applicability: Designed for European ecosystems Main Barriers: Technical complexity, ecological mismatch, data inconsistency, lack of local adaptation capacity
InVEST	Most widely used ecosystem services modelling tool Very well documented Large user community	Relatively limited use to date in ecosystem accounting. Limited accounting for beneficiaries/ecosystem service use	Main Barriers: Pollination module data gaps, agricultural system complexity, spatial data scarcity, inadequate beneficiary mapping

[29] https://seea.un.org/sites/seea.un.org/files/biophysical_modelling_of_es_and_ecosystem_accounting_finallg.pdf

Biophysical modelling approach	Pros	Cons	India Context Applicability
ARIES	Offers very rapid Ecosystem Services assessment through ARIES Explorer tool, high level of expert-level customizability through ARIES Modeler tool Artificial intelligence approach selects the most appropriate data and models for use in each application, plus provenance for transparency "Global yet customizable" modelling approach offers the ability to compile ecosystem accounts in data-scarce regions Provides infrastructure to make data and models interoperable and reusable, advancing global SEEA EA efforts	Benefits of data & model interoperability, path to achieve it are poorly understood by most scientists Models for incorporating beneficiaries/ ecosystem service use are not yet fully built out	Adoption/operational barrier: the benefits and pathway for achieving data & model interoperability are "poorly understood by most scientists," which becomes a capacity constraint for deploying pollination models at scale. Beneficiary/service-use not fully built: ARIES notes that models for incorporating beneficiaries/ecosystem service use are not yet fully built out-this limits producing pollination service use accounts (e.g., linking pollination to specific crop producers/regions). Underlying evidence gaps: pollination values are hard to estimate precisely and information on benefits through the supply chain is often lacking-this weakens conversion of biophysical outputs into robust service values.

Chapter- 4 Accounting for Pollination Services: Methods and Adaptation

Valuation of Pollination

4.1 Pollination services refer to the contribution of pollinators to the fertilization of crops and other plants whose fruits, seeds or genetic diversity are used or enjoyed by economic units and households. Pollination is interpreted broadly to include both its role in sustaining agricultural production and its role in maintaining species abundance, diversity and forest regeneration. The common measures used for measuring pollination includes the area of pollinator-dependent crops, yields attributable to pollinators and indicators such as the number of pollinator visits.

4.2 Pollination services operate along two closely linked dimensions:

Forest pollination, where pollinators maintain forest regeneration, structure and non-timber forest product (NTFP) flows. In forest ecosystems, pollination and seed dispersal together sustain natural regeneration and forest succession.

Crop pollination, where pollinators enhance the quantity and quality of agricultural output. Crop pollination is defined as 'the ecosystem contribution by pollinators to the production of the crops. The contributions can be reported in tonnes of pollinator-dependent crops that can be attributed to pollinators, by type of crop.

Approaches to Valuing Ecosystem Services[30]

4.3 There are two types of methods for valuing ecosystem services: revealed preference methods and stated preference methods. Revealed preference methods infer value based on certain physical parameters, references, or data, whereas stated preference methods involve asking people how much they are willing to pay or willing to accept for a particular environmental service.

4.4 The most significant revealed preference methods include calculation or estimation of replacement cost, avoided cost, change in productivity, hedonic pricing (related to pleasure/ recreational value), and travel cost. The commonly used stated preference method is the contingent valuation method (CVM) and choice experiment. CVM involves asking respondents how much they would be willing to pay or accept for a particular service. It requires conducting a survey to elicit the willingness to pay (WTP) or willingness to accept (WTA) payment for a specified service.

[30] https://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/econvaluepoll1.pdf

4.5 For the pollination service, it is anticipated that Contingent Valuation Methods or Choice Experiments are not suitable. The reason is that these valuation methods require respondents to have a sound knowledge of the quantitative contribution that pollination makes to agricultural production in their field. In view of the substantial uncertainties that exist in ecological literature on the contribution of pollination to crop growth under specific ecological circumstances it is not likely that farmers have a quantitative comprehension of this. Furthermore, application of this method requires a clear payment vehicle including a scenario of how pollination services would be reduced or enhanced as a function of the willingness to pay of the farmer, which is also difficult to envisage. Another way of applying the stated preference method is to conduct a group valuation or discourse-based valuation of a service. This method can be applied to value any service, including a pollination service, and would require several rounds of consultation. Its main limitation is that it is difficult to reach a consensus on value.

4.6 There are a number of approaches that can be followed to value the pollination service. Some of them, which holds wider applicability has been discussed in detail which include (i) using market prices; (ii) the damage cost method; and (iii) the production factor method - have been used to assess the value of pollination services.

(i) Market prices method

4.7 The market price method estimates the economic value of ecosystem services by observing actual market transactions relating to those services. For pollination, this refers primarily to the hiring of commercial beehives. Under competitive market conditions, the price paid for renting a hive is interpreted as revealing the marginal value of pollination services to farmers.

4.8 Total economic value in this context consists of consumer surplus and producer surplus. Consumer surplus is represented by the area under the demand curve for rented hives, while producer surplus is measured as beekeepers' revenues from hive rental and honey sales minus their input, operating and capital costs, including labor, transport of hives, equipment and other expenses.

4.9 For national reporting across crops, comparable and regular data on pollination-service prices and coverage are not consistently available, and the required market conditions may not hold uniformly across crops and regions. Therefore, this method is not used in the report, mainly due to data comparability and applicability constraints.

(ii) Cost-based methods (preventive expenditure/damage costs avoided/replacement costs)

4.10 Cost-based methods, including preventive expenditure, damage cost avoided and replacement cost, derive the value of pollination services from the costs incurred when natural pollination is degraded or lost. In the case of pollination, these costs may consist of the artificial regeneration instead of natural regeneration, or in some situations the labor and material costs of hand pollination.

4.11 In practical applications, scenarios are often framed in terms of "with pollination" and "without pollination" conditions. The reduction in output due to a decline in pollination is quantified, and the associated cost of measures taken to prevent or compensate for this loss is used as an estimate of the value of the pollination service.

4.12 The quantification of economic value of pollination and seed dispersal services in forest ecosystems represents a critical component of environmental accounting. The economic and ecological significance of these services extends across multiple dimensions: they ensure forest regeneration, maintain biodiversity, sustain ecosystem resilience, and provide the foundation for long-term forest productivity. This comprehensive methodology for valuing forest-based pollination services is grounded in the principle that the economic value of an ecosystem service can be estimated by replacement-cost approach. In this approach, value is estimated by calculating the cost of replacing or substituting that service through human effort or technology. For pollination and seed dispersal in forests, this translates to quantifying the cost required to artificially replicate the natural forest regeneration that occurs through pollinator and fauna-mediated seed dispersal. The step-by step methodology is depicted in table 10.

Table 10: Methodology for Forest Pollination Services

Steps	Method of Estimation	Tentative Data Sources / Parameters / Notes
1	**Compilation of forest area and regeneration indicators by forest type:** For each State/UT, list forest type groups (including plantations/TOF as applicable), compile total forest area (sq. km) for each type, and compile the corresponding regeneration indicator (e.g., "% to ideal regeneration" or an equivalent proxy).	Forest type-wise area and regeneration indicators from official forest statistics (e.g., FSI/ISFR or equivalent State forest assessments).
2	**Standardization of regeneration indicator across forest types:** Convert the regeneration indicator into a standardized index for comparability across forest types (e.g., on a 0–100 scale). Standardization can be done using an internally consistent reference (such as the best-performing category, an empirical benchmark, or a documented "ideal" level).	Requires selection of a reference benchmark (documented and reproducible). Benchmark may be updated when improved regeneration datasets or revised baselines become available.
3	**Year-specific artificial regeneration cost (current prices):** Establish a base unit cost for artificial regeneration (Rs/km²) from an official scheme, programme guideline, or study. Update this base cost to each analysis year using an accepted price adjustment mechanism (e.g., a suitable deflator or inflation index), ensuring consistency across years.	Base cost from scheme/programme guidelines or published studies; annual price adjustment using an officially published inflation/deflator series (the specific index used should be stated and kept consistent).

Steps	Method of Estimation	Tentative Data Sources / Parameters / Notes
4	**Derivation of a base pollination value per km² (year t):** Derive a base per-km² value linked to regeneration support functions by applying a pollination attribution factor to the annual regeneration cost. This attribution factor should be treated as a parameter (range/sensitivity) rather than a fixed universal constant.	Attribution factor based on literature/empirical justification, expert consultation, or sensitivity analysis (document the basis; update when improved evidence becomes available). This should be based on some estimate of the proportion of dominant, endemic and rare trees and shrubs that depend on cross-pollination.
5	**Pollination value per km² by forest type and year:** For each forest type (i) and year (t), estimate pollination value per km² as: $\mathbf{PV_{i,t} = Base\ Value_t \times (Standardized\ Regeneration\ Index_i / 100)}$. This links service values to observed regeneration.	Uses standardized regeneration index from Step 2 and base value from Step 4.
6	**Total pollination-support value by forest type and aggregate (year t)** – Multiply per-km² value by forest area: $\mathbf{TV_{i,t} = PV_{i,t} \times Area_i}$. Convert to required reporting units (e.g., million ₹, ₹ crores) and sum across forest types to derive State/UT totals and higher-level aggregates.	Forest-type area from Step 1

Note 1: Some studies have operationalised the computation using fixed reference parameters to enable standardised estimation across forest types and years. In particular, a plantation regeneration rate of 62.6% has been used as a reference benchmark for adjusting regeneration indices across forest types. Additionally, an attribution factor has been applied in some implementations by assuming 50% of artificial regeneration cost is attributable to pollination and seed dispersal processes.[31]

Note 2: The Forest Pollination Services methodology provides a useful and transparent framework for approximating pollination values where direct measurement is not feasible. However, for the present compilation, it is not being adopted primarily due to practical constraints related to parameter validity and updateability. Therefore, while the method remains conceptually relevant and may be revisited when updated coefficients and rate schedules become available.

4.13 For Crop pollination, the replacement-cost method estimates the value of pollination by using the cost of actions taken to replace or compensate for lost pollination, such as hand pollination or other interventions. This approach requires a clear and defensible "with pollination" versus "without pollination" situation, and reliable, crop-specific information on the costs actually incurred to prevent or offset production losses. Since standardized replacement-cost data are not consistently available for all crops/regions required for this report, the method is not adopted here due to practical data constraints.

(iii) Change in Productivity method

4.14 Change in Productivity method are particularly useful for valuing ecosystem services that operate as inputs to market production. In these approaches, pollination is treated as one factor of production among others. The method proceeds in two steps. First, the physical effect of changes in pollination on agricultural output is estimated. Second, the resulting change in marketed output is valued using price information.

[31] Verma M, Negandhi D, Wahal A K, Kumar R. Revision of rates of NPV applicable for different class/category of forests. Indian Institute of Forest Management. Bhopal, India. June 2013.
Ramachandra, T.V., Vinay, S., Bharath, Setturu, and Bharath, H. Aithal (2022). Valuation of Ecosystem Services, Karnataka State, India. Available at: http://wgbis.ces.iisc.ernet.in/energy/NCAVES
Verma, M., Lal, R.B., Negandhi, D.,Khanna, C., Shahi G. Ecosystem Services Valuation and Accounting of Himachal Forests Indian Institute of Forest Management. Bhopal, India. September 2016.

4.15 The output of a crop can be represented as a function of purchased inputs (such as fertilizers, labor and machinery), the flow of pollination services and fixed factors such as land and capital. If (y) denotes output, (x) the vector of purchased inputs, (q) the level of pollination services and (k) fixed factors, the production function can be written as

$$\mathbf{y = f(x, q, k)}$$

Output is sold at price (p), and inputs are purchased at prices (w). Under competitive conditions, welfare is measured as the sum of competitive profits and consumer surplus, i.e., the area under the demand curve for (y) minus the costs of the inputs.

4.16 In principle, a full welfare assessment requires information on how both demand and supply curves shift when pollination changes, as well as the resulting changes in equilibrium prices and quantities. It is also necessary to ensure that changes in output attributed to pollination are measured while holding other inputs constant. In practice, such detailed information is rarely available for multiple crops and regions.

4.17 In absence of full information, a simplifying assumption is often adopted that changes in local pollination services do not significantly affect markets for the final crop, so prices remain unchanged. Under this assumption, the welfare change can be approximated by the change in quantity produced multiplied by the farm-gate price of the crop. This "effect on production" method is widely used where it is difficult to estimate full demand and supply schedules, but where reasonably robust data on yields and prices are available which has been further discussed in next section.

The comparison of valuation methods is discussed in table 11.

Table 11: Comparison of valuation methods

Valuation method	Remarks	Principal data requirements
Market prices of bee hives	The price of rented bee colonies provides, under a number of conditions, an indication of the marginal value of pollination. These condition include: (i) There is a (non-distorted) market for the pollinator, and (ii) there is full information on the impacts of pollination on crop production among farmers and beekeepers. This assumption may or may not be realistic depending on the crop and country.	Price data on bee rentals per crop per season
Cost-based methods	This method can be used to calculate the value of (natural) pollination, in particular if there is a clear with/without pollination scenario. The method is mostly applicable to the scale of the farmer of the community as it does not involve analysis of market responses to reductions or increases in the supply of the pollination service	Impact on production of the (potential / temporary / actual) loss of the pollination service - Costs of responses (e.g. labour costs for hand-pollination; or costs of bee rentals where available) - Price data of the affected crops
Change in Productivity method	To assess the economic value of pollination for specific crops at the scale of a country. This method requires a change in production related to pollination multiplied with the economic farm-gate price of the product.	Crop Production Farm-gate price

Methodology adopted for Crop Pollination

4.18 The economic value of the contribution of pollinators to agriculture is assessed using a dependence-ratio-based bio-economic approach, a simplified version of Change in Productivity method. The method rests on the assumption that the impact of pollinators on agricultural output can be quantified using crop-specific dependence ratios that express the proportional reduction in output that would occur in the absence of pollinators.

4.19 For each crop, three quantities are required:

- Total value of the crop;
- Dependence ratio of the crop on pollinators; and
- Economic value of pollination.

The **total value of the crop** indicates the economic importance of each crop and is calculated as the product of its total production (in tonnes) and its unit price (per tonne) at current prices. These values are obtained from National Accounts estimates of crop output.

The **dependence rate (DR)** represents the level of dependence of a crop on pollinators for fruit or seed production. DR values are drawn from published literature (Chaudhary and Chand, 2017), which aggregates experimental and observational evidence on pollinator dependence for different crops and crop groups.

The **economic value of pollination** is the share of the total crop value attributable to pollinators. For each crop, PVO is derived as the product of VO and DR. PVO can then be aggregated across individual crops to derive values for broader crop categories.

The detailed procedure for estimating pollination contributions using the crop-specific dependence ratio method is presented in Table 12. This table outlines the sequential steps used to quantify the proportion of crop production that can be attributed to pollination services. The method begins with the identification of pollinator-dependent crops and the assignment of appropriate dependence ratios based on established scientific classifications. These ratios are then applied to the value of output data to estimate the pollination-attributed share of production.

Table 12: The methodology of Economic valuation of Crop Pollination Services

Step	Item	Method of estimation (at current prices)
1	Value of output of crops (VO)	Estimates are taken from the National Accounts[32]
2	dependence rate (DR)	Estimates are taken from (Chaudhary and Chand, 2017)[33]
3	Pollination attributed Value of output (PVO) at crop level	Value of Service = VO*DR

Note 1: The methodology estimates only the pollination-attributed value of output (PVO), isolating the contribution of animal-mediated pollination to crop production. All other production conditions and farming inputs (such as land, labour, irrigation, fertilisers, plant protection measures, and management practices) are not considered in the estimation.

Note 2: Honey production and related apiculture outputs are not addressed in the current framework. Although honey is intrinsically linked to bee foraging behaviour and pollination processes, its treatment requires a distinct accounting approach (as a marketed product and associated industry output).

Methodology adopted by National Accounts for Value of output of crops (VO)[34]

4.20 In the National Accounts, for the valuation of output of crops, the State/UT-wise estimates of area and production of major crops are sourced from the Ministry of Agriculture

[32] https://www.mospi.gov.in/publications-reports/innerpage/431
[33] CHAUDHARY, O.P. and CHAND, R. (2017). Economic benefits of animal pollination to Indian agriculture. The Indian Journal of Agricultural Sciences, 87(9). doi: https://doi.org/10.56093/ijas.v87i9.73903.
[34] https://www.mospi.gov.in/sites/default/files/publication_reports/Brochure2025_r.pdf

and Farmers Welfare (MoAFW). The estimates of area and production of fruits and vegetables are obtained from Horticulture division of MoAFW. The estimates of area and production of plantation crops viz. tea, coffee, rubber, areca nut, cashew nut and cocoa are obtained from the respective commodity boards. Also, for some State/UT specific crops, DES of the concerned State/UT provides the area and production of such crops. For evaluation purpose of these crops, the producers' prices known as Farm Harvest Price (FHP) correspond to average FHP ruling in the nearest primary markets during the peak arrival periods, which is normally within 2 months after the crop is harvested. The same is furnished by the respective State/UT DES to MoSPI.

4.21 The different groups of crops under the crop sub-sector in the NAS are: (1) cereals, (2) pulses, (3) oilseeds, (4) sugars, (5) fibres, (6) indigo, dyes and tanning material, (7) drugs and narcotics, (8) condiments & spices, (9) fruits & vegetables, (10) floriculture, (11) other crops, (12) by-products, and (13) crops produced in kitchen garden.

Methodology adopted for dependence rate (DR)

4.22 For estimating crop pollination services, the dependence rate (DR) is used as a crop-specific coefficient that represents the proportional reduction in output expected in the absence of animal pollination. In the paper, DR values are derived by compiling and reviewing experimental and observational evidence on pollinator exclusion and flower visitation (including Indian studies and crop-wise evidence), and then classifying crops into dependence groups based on the range of yield reduction (%) without pollinators. Crops are grouped into standard dependence categories, and each category is assigned a representative DR value (median/mean) used for valuation: Essential (90–100% → DR 0.95), Great (40–90% → DR 0.65), Modest (10–40% → DR 0.25), Little (0–10% → DR 0.05), and No increase (0% → DR 0.00). Where studies show variation across locations or methods, extreme values are excluded and median values are applied; wind-pollinated and other crops are placed in DR 0.00, and crops lacking evidence are treated as "unknown". The paper has assess pollination dependence for a total of 211 crops/commodities comprising 190 crops and 21 commodities and identify 108 crops as animal-pollination dependent with assigned dependence-rate (DR) coefficients. Within these 108 crops, the paper groups them into standard dependence categories: 14 crops as DR 0.95, 34 as DR 0.65, 29 as DR 0.25, 31 as DR 0.05 and rest under DR 0.00.

4.23 **Statistical Limitation:** The report does not cover the full range of crops cultivated in India. For certain minor crops, pollination dependence rates are available; however, corresponding value of output data are not compiled and reported separately, which does not permit application of the dependence rates for estimation. Accordingly, these crops are not covered in the present analysis. Conversely, for some crops, value of output data may be available, but pollination dependence rates are not currently established and would require further research and validation. In addition, a set of crops is not included where both the value of output data and pollination dependence rates are presently unavailable or undefined.

Chapter- 5
Crop Pollination Services in India: A Decade of Change and Insights

Pollination: Role in Crop Production

5.1 This chapter quantifies India's reliance on pollinator for crop production and traces changes in pollination-dependent production over the decade from 2012-13 to 2021-22, following the methodological framework set out in Chapter 4 (Sections 4.18- 4.22). It compiles crop-wise estimates of pollination attributed value of output of crops and its contribution in the economy. The analysis demonstrate that pollinators provide an essential regulating service supporting agricultural productivity and food security, even though such contributions often remain invisible in conventional national accounts.

Pollination dependent crop categorization

5.2 Figure 9 presents a crop-wise classification of animal-mediated pollination dependence, expressed through a Dependence Rate (DR) that ranges from 0.00 to 0.95.

Figure 9: Examples of Pollination Dependence Crops

It groups agricultural and horticultural commodities into five bands, No Dependence (DR 0.00), Little Dependence (DR 0.05), Modest Dependence (DR 0.25), Great Dependence (DR 0.65) and Essential Dependence (DR 0.95), to indicate how strongly crop yields rely on pollinators for fruit/seed set and productivity. The listing shows that major cereals and several staples fall largely in the no-dependence category, while many oilseeds, fruits, vegetables and spices are either in great or essential dependence, highlighting that a substantial share of crop output is enabled by ecological inputs that are not directly priced in conventional production accounts. In the SEEA context, such dependence rates provide a practical basis to attribute a pollination-enabled share of crop production and subsequently support monetary measurement of ecosystem contributions, thereby improving the visibility of ecosystem assets in economic analysis.

Economic valuation of pollination Services

5.3 The section presents the economic valuation of pollination services and covers four interlinked components: (i) estimation of the Pollination-attributed Value of Output (PVO) by major crop categories; (ii) assessment of the share of PVO in the total value of output-both within each crop category and for total crops; (iii) analysis of the decadal change in PVO over the reference period; and (iv) identification and discussion of pollination-dependent crops, presented under three sub-groups, namely fruits and vegetables, condiments and spices, and other pollination-dependent crops.

Pollination-attributed Value of Output (PVO) by Crop Category

5.4 Table 13 presents the Pollination-attributed Value of Output (PVO) disaggregated by major crop categories for the period 2012-13 to 2021-22.Total PVO of all the crops increases consistently over the decade, rising from ₹115.41 ('000 crore) in 2012-13 to ₹266.33 ('000 crore) in 2021-22.

The increase accelerates in the latter part of the series, moving from ₹173.43 ('000 crore) in 2018-19 to ₹200.60 ('000 crore) in 2019-20, ₹227.15 ('000 crore) in 2020-21 and ₹266.33 ('000 crore) in 2021-22, indicating a widening economic footprint of animal-mediated pollination in crop output over time.

Table 13: Pollination-attributed Value of Output (PVO) across Crop Categories (in ₹ '000 crores)

Crop Category	Pulses	Oilseeds	Fibres	Drugs & narcotics	Condiments & spices	Fruits & vegetables	Other crops	Total
2012-13	1.25	36.4	17.14	1.96	9.92	47.46	1.28	115.41
2013-14	1.5	36.87	20.64	1.82	11.54	58.25	1.52	132.13
2014-15	1.84	34.78	17.7	2.44	13.95	61.55	1.12	133.38
2015-16	2.4	35.13	15.8	2.33	15.31	69.5	0.86	141.34
2016-17	3.26	38.48	20.57	2.49	17.87	72.06	0.57	155.29
2017-18	2.56	41.75	20.32	2.52	19.66	86.08	0.52	173.4
2018-19	2.3	45.96	18.88	2.6	18.72	84.53	0.43	173.43
2019-20	2.53	49.54	23.47	2.02	24	99.11	0.3	200.98
2020-21	3.18	66.05	23.38	2.26	27.95	104.07	0.26	227.15
2021-22	3.2	85.06	29.61	2.5	28.36	117.25	0.34	266.33

Note 1: Cereals and sugars are not included in this table, as their pollination-attributable crop value is zero

Note 2: The category "Indigo, dyes & tanning material" has not been included, as pollination dependence within this group is primarily limited to indigo, and a separate value of output for indigo was not available for estimation.

5.5 Among crop groups, Fruits & vegetables account for the largest share throughout the period, increasing from ₹47.46 ('000 crore) in 2012-13 to ₹117.25 ('000 crore) in 2021-22. In proportional terms, the contribution of this group remains high and stable about 41.19% of the total in 2012-13 and 44.10% in 2021-22, showing that horticulture continues to be the dominant driver of pollination-attributable value.

5.6 Oilseeds form the second-largest component and show a marked expansion over the decade. The PVO for oilseeds rises from ₹36.40 ('000 crore) in 2012-13 to ₹85.06 ('000 crore) in 2021-22. While the share remains broadly stable (around one-third of the total), the absolute increase is substantial, particularly after 2018-19. Within the remaining groups, Condiments & spices show a strong and sustained increase raising their share from 8.6% to 10.7% over the period. This pattern highlights that pollination-attributable value is not confined to horticulture and oilseeds; it is also increasingly significant for spice and condiment systems, where pollination influences both yield formation and output quality.

5.7 Fibres increase from ₹17.14 ('000 crore) to ₹29.61 ('000 crore) over the decade, but their relative importance declines from 14.87% (2012-13) to 11.14% (2021-22), implying slower growth compared to the leading groups. Pulses remain a small component in absolute terms (₹1.25 to ₹3.20), with a nearly stable share (~1-1.5%). Drugs & narcotics remain broadly stable around ₹2-3 ('000 crore) and decline in share over time. Other crops remain negligible and decrease in relative contribution from ₹1.28 ('000 crore) to ₹0.34 ('000 crore). The table indicates that the rising total PVO is structurally driven by three crop groups- Fruits & vegetables, Oilseeds, and Condiments & spices-which together account for the bulk of pollination-attributable value in each year.

Share of Pollination-attributed Value of Output (PVO) in the total value of output- within crop category and total crops

Share within each crop category

5.8 The figure 10 is a heatmap for the share of pollination-attributed value of output (PVO) within crop category for the period 2012-13 to 2021-22. Rows represent crop categories and columns represent years. The darker shade indicates a higher percentage share, while lighter shades indicate lower dependence/attribution in value terms. Oilseeds consistently have the highest shares (~27-32%), followed by fibres (~22-23%), indicating strong and stable pollination linkage. Condiments & spices decline noticeably over the decade (~21% to ~14%), while fruits & vegetables remain broadly stable (~13-15%). Pulses (~2-2.5%), drugs & narcotics (~3-5%), and other crops (falling to ~0.3%) contribute relatively small shares.

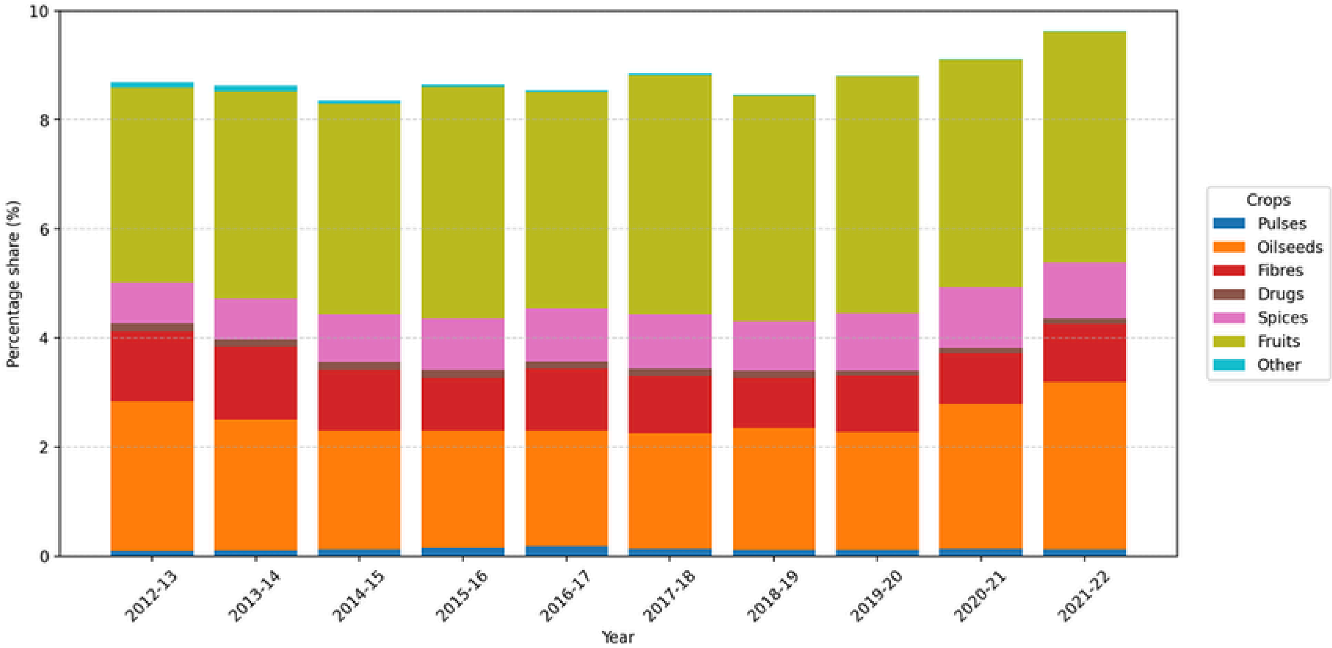
5.9 It highlights two important messages: (i) pollination-attributed shares are structurally highest and persistent in oilseeds and fibres, and (ii) the decade shows a notable reduction in the spice/condiment share, while fruits & vegetables remain broadly stable. This visual thus helps identify where pollination-linked economic exposure is consistently high (oilseeds, fibres) and where the relative contribution has changed over time (spices).

Figure 10: Share of pollination-attributed value of output (PVO) within crop category (%)

Share in total crops

5.10 The figure 11 presents how the pollination-attributed value of output (PVO) contributes to total crop output value over 2012–13 to 2021–22. Each vertical bar represents a year, and the total height of the bar is the overall share (%) of pollination-attributed value in total crop output value for that year. The coloured segments within each bar indicate how much each crop category contributes to that overall share.

Figure 11: Share of pollination-attributed value of output (PVO) of each category in the Value of Output (VO) of total crop (%)



5.11 The aggregate share stays broadly within the 8-10% range, with a gradual rise towards the end of the series. The overall share is around ~8.3-8.7% during the early and middle years (notably the lower level around 2014-15 and 2018-19), and increases to its highest level by 2021-22 (close to ~9.6%), indicating that pollination-attributable value forms an increasing component of total crop output in the later period.

5.12 In terms of composition, fruits & vegetables contribute the largest share every year, forming the most prominent segment of each bar (roughly around 3.5-4.4 percentage points).

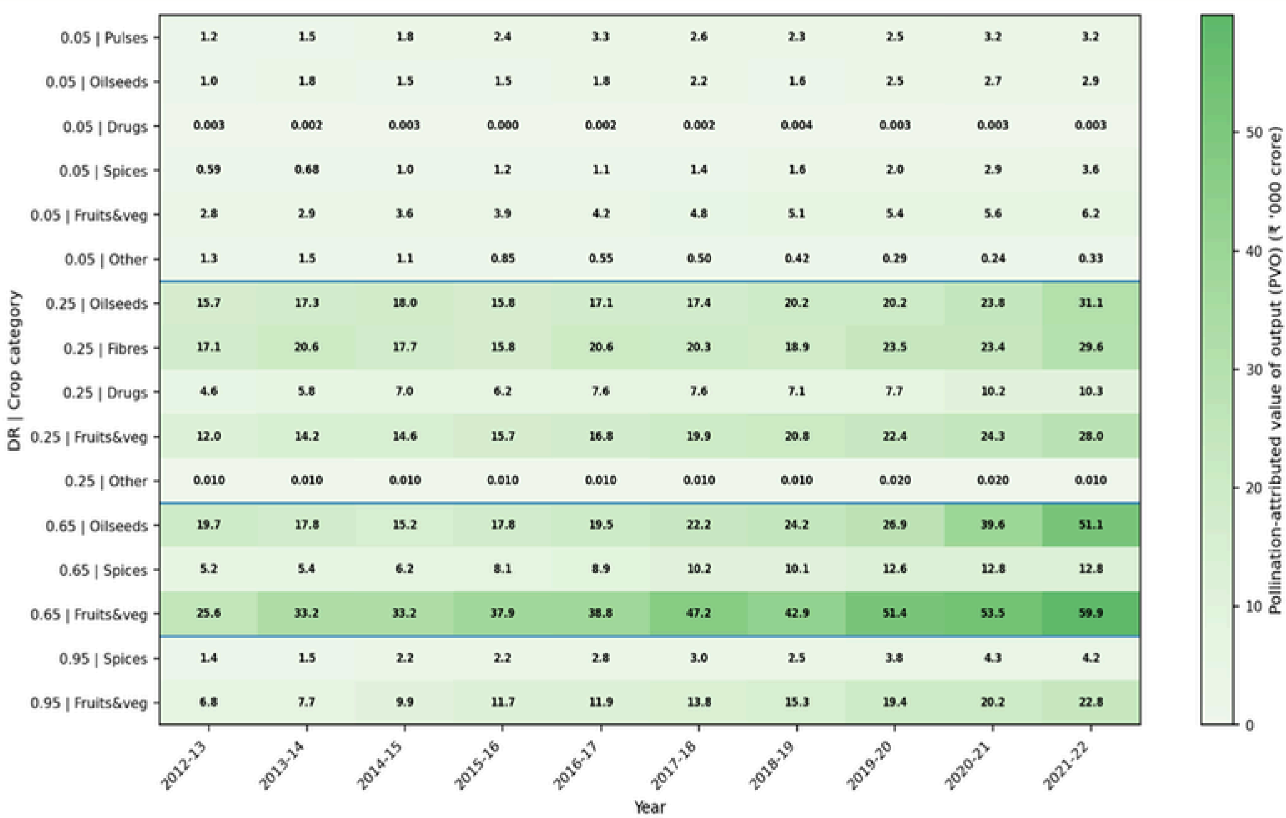
This indicates that horticulture consistently accounts for the largest portion of pollination-attributable value within the overall crop output framework. Oilseeds are the second-largest contributor across all years (approximately 2.1-3.1 percentage points), and their contribution increases notably in the last two years, which is one of the key reasons why the overall total bar height rises in 2020-21 and 2021-22. Fibres and spices add moderate shares, while pulses, drugs & narcotics, and other crops contribute only small amounts.

5.13 Figure 11 highlights two central observations: (i) pollination services contribute a substantial and slightly rising share of total crop output over the decade, and (ii) the aggregate pattern is largely driven by fruits & vegetables and oilseeds, which together dominate the pollination-attributable share and explain most of the late-period increase.

Crop-category PVO by Dependence Rate Group

5.14 Figure 12 presents the pollination-attributed value of output (PVO) across crop categories for the period 2012-13 to 2021-22.

Figure 12: PVO across Crop Categories by Pollination Dependence Class



There is a clear pattern emerges in terms of concentration by dependence class. Categories in higher dependence groups account for the largest PVO levels, most notably fruits & vegetables under DR 0.65, which remains consistently high and increases sharply over time. Oilseeds within higher dependence classes also exhibit a marked increase, particularly in the later years, indicating a strengthening pollination-attributed component. Moderate dependence categories (DR 0.25), especially fibres and oilseeds, also contribute substantially and show an overall rising trend, though their levels remain below the DR 0.65 fruits & vegetables series.

5.15 In contrast, crop categories grouped under low dependence (DR 0.05) display relatively smaller PVO magnitudes across the time series, reflected in lighter shading and lower cell values. The very high dependence class (DR 0.95) appears concentrated in fewer crop categories, but shows a consistent upward movement, with fruits & vegetables rising steadily and condiments & spices increasing more moderately. Overall, the heatmap indicates that PVO is systematically higher for crop categories with greater pollination dependence and that the pollination-attributed contribution strengthens in the later years, particularly within higher dependence groups.

Decadal Change

5.16 Table 14 presents pollination attributed value of crop output (PVO) and the corresponding pollination share in crop GVO for two time points, 2012-13 and 2021-22, across major crop categories to assess decadal changes. In line with the SEEA approach, the table uses monetary measurement to make the contribution of an ecosystem service-animal-mediated pollination-visible within conventional production aggregates such as Gross Value of Output (GVO).

Table 14: Decadal Change in Pollination- attributed Value of Output (PVO) across Crop Categories (in ₹ ’000 crores)

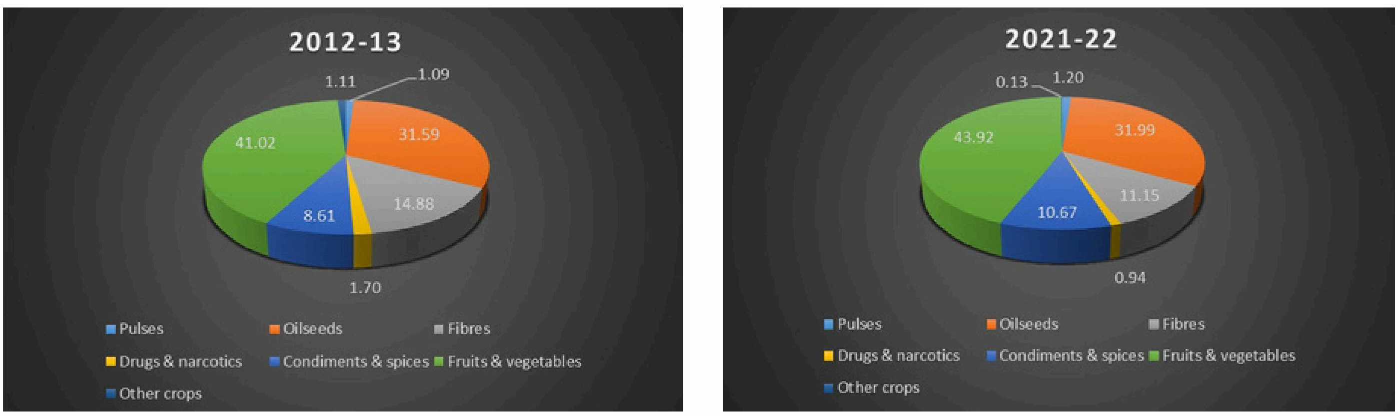
Crops Categories	2012-13			2021-22		
	Pollination-attributed Value of Output (PVO)	Pollination Share in total Crop GVO (%)	Pollination Share within Crop Category GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in total Crop GVO (%)	Pollination Share within Crop Category GVO (%)
Pulses	1.25	0.09	2.01	3.2	0.12	2.09
Oilseeds	36.4	2.74	31.95	85.06	3.07	31.65
Fibres	17.14	1.29	23.48	29.61	1.07	22.93
Drugs & narcotics	1.96	0.15	3.89	2.5	0.09	3.28
Condiments & spices	9.92	0.75	21.41	28.36	1.03	14.18
Fruits & vegetables	47.46	3.57	13.99	117.25	4.24	14.05
Other crops	1.28	0.1	1.3	0.34	0.01	0.31
Total	**115.41**	**8.68**	**98.02**	**266.33**	**9.62**	**88.48**

Note 1: Cereals and sugars are not included in this table, as their pollination-attributable crop value is zero.

Note 2: **Pollination Share in Crop GVO** (%): Share of PVO in Gross value of output of Crop; **Pollination Share within Crop Category GVO (%)**: share of PVO in the total value of output of each crop category.

5.17 The total pollination-attributable value increases markedly from ₹115.41 ('000 crore) in 2012-13 to ₹266.33 ('000 crore) in 2021-22. The aggregate pollination share in total crop GVO rises from 8.68% to 9.62%, indicating a higher pollination-attributable component within the set of crops reported.

Figure 13: Contribution of each crop category



5.18 Across categories in figure 13, fruits and vegetables category contribute the highest pollination-attributable value in both years, increasing from ₹47.46 ('000 crore) in 2012-13 to ₹117.25 ('000 crore) in 2021-22, with the pollination share in total crop GVO rising from 3.57% to 4.24%. Oilseeds category also show a substantial increase in PVO, from ₹36.40 ('000 crore) to ₹85.06 ('000 crore), and their pollination share in crop GVO rises from 2.74% to 3.07%, indicating sustained and growing dependence of this output category on pollination services.

5.19 Fibres category also registered increase in PVO from ₹17.14 to ₹29.61 ('000 crore), while their pollination share declines from 1.29% to 1.07%, suggesting that output growth was not matched by a proportional increase in pollination-attributed share. For condiments and spices category, PVO rises from ₹9.92 to ₹28.36 ('000 crore), with the pollination share in crop GVO increasing from 0.75% to 1.03%, reflecting the high pollination sensitivity of several commercial spice crops. Pulses and drugs & narcotics register comparatively smaller PVO values in both years, though PVO increases from ₹1.25 to ₹3.20 ('000 crore) for pulses and from ₹1.96 to ₹2.50 ('000 crore) for drugs & narcotics; their pollination shares remain below 0.15%. Other crops category show a decline in PVO from ₹1.28 to ₹0.34 ('000 crore), and their pollination share falls from 0.10% to 0.01%, indicating a reduced pollination-attributed contribution within that residual category over the period.

Pollination-dependent crops

5.21 In this section, selected pollination-dependent crops have been examined across multiple crop categories to illustrate the extent to which animal-mediated pollination contributes to agricultural production. The crops have been drawn from major groups such as pulses, oilseeds, fruits & vegetables, fibres, condiments and spices, drugs & narcotics, and other crops, reflecting the diversity of India's crop portfolio. For each crop, the dependence rate (DR) is used to identify the pollination-enabled component of output, and the resulting pollination-attributable crop value (PVO) is presented alongside the pollination share in crop GVO for 2012-13 and 2021-22.

Fruits and Vegetables

5.22 The estimates in table 15 indicate that crops with high dependence rates contribute substantially to pollination-attributed value where their production base is large. Muskmelon (DR 0.95) increases from ₹0.66 ('000 crore) in 2012-13 to ₹2.23 ('000 crore) in 2021-22, and its pollination share rises from 0.05% to 0.08%, reflecting growth in pollination-enabled output over the decade. Similarly, watermelon records a marked increase in PVO from ₹2.66 to ₹5.39 ('000 crore), with the pollination share remaining around 0.20%-0.19%, suggesting that output growth occurred with a broadly stable pollination share in crop GVO.

Table 15: Pollination Contribution to selected Fruit Output: PVO and Share in Crop GVO (in ₹ ’000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Muskmelon	0.95	0.66	0.05	2.23	0.08
Watermelon		2.66	0.2	5.39	0.19
Strawberry	0.65	0.003	0.0002	0.03	0.001
Pear		0.48	0.04	0.71	0.03
Guava		2.52	0.19	9.76	0.35
Apple		4.16	0.31	6.82	0.25
Mosambi		1.02	0.08	1.76	0.06
Peach/plum		0.45	0.03	0.61	0.02
Cherry		0.03	0.003	0.1	0.004
Orange	0.25	2.87	0.22	9.57	0.35
Lichi		0.64	0.05	1.01	0.04
Pomegranate		0.54	0.04	3.86	0.14
Ber		0.15	0.01	0.32	0.01
Mango	0.05	2.09	0.16	4.55	0.16
Papaya		0.31	0.02	0.63	0.02
Other citrus fruit		0.06	0.004	0.05	0.002

5.23 Guava records a major increase in pollination-attributed value from ₹2.52 to ₹9.76 (’000 crore), with its pollination share rising from 0.19% to 0.35%, indicating stronger pollination-linked output growth.

Apple's PVO also increases, but its share declines (0.31% to 0.25%), suggesting slower growth in the pollination-attributed component relative to total output. Even moderately dependent crops show large gains at scale: orange rises from ₹2.87 to ₹9.57 ('000 crore), with share increasing from 0.22% to 0.35%. Other fruits show mixed trends, such as pomegranate increasing strongly (0.04% to 0.14%) while mosambi grows modestly with a slight decline in share (0.08% to 0.06%).

5.24 Crops with low dependence contribute relatively smaller pollination-attributed shares, though their PVO can still rise with overall output expansion. For instance, mango (DR 0.05) increases from ₹2.09 to ₹4.55 ('000 crore), while its pollination share remains stable at 0.16% in both years. Minor crops such as strawberry and other citrus fruits show very small PVO values and correspondingly negligible shares, which is consistent with their limited production base at the national level. Overall, the table demonstrates that the pollination-attributed component of fruit output increased substantially between 2012-13 and 2021-22, with particularly large absolute gains in crops such as guava, orange, watermelon, apple, and mango.

5.25 The table 16 provides crop-wise estimates of the economic value of output attributed to pollination services (PVO) and the corresponding pollination share in crop GVO for selected vegetables during 2012-13 and 2021-22, together with their dependence rate (DR). Tomato (DR 0.65) contributes the largest PVO in both years, increasing from ₹13.54 to ₹32.22 ('000 crore), with its pollination share rising from 1.02% to 1.16%. High-dependence cucurbits such as pumpkin (DR 0.95), bitter gourd, and bottle gourd also show strong growth in PVO and their shares in crop GVO. In contrast, sweet potato (DR 0.05) remains negligible in both PVO and pollination share, reflecting low dependence on pollination services. Overall, the table indicates that the pollination-attributable component of vegetable output increased markedly between 2012-13 and 2021-22, with particularly large increases for tomato and cucurbit vegetables such as pumpkin, bottle gourd, and bitter gourd.

Table 16: Pollination Contribution to selected Vegetables Output: PVO and Share in Crop GVO (in ₹ '000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Pumpkin	0.95	0.31	0.02	3.42	0.12
Bitter gourd		1.51	0.11	4.33	0.16
Bottle gourd		1.47	0.11	4.69	0.17
Parmal		0.25	0.02	2.68	0.1
Tomato	0.65	13.54	1.02	32.22	1.16
Cucumber		0.4	0.03	1.88	0.07
Brinjal	0.25	4.95	0.37	7.99	0.29
Okra		2.84	0.21	5.21	0.19
Sweet potato	0.05	0.08	0.01	0.13	0.005
Lemon		0.25	0.02	0.68	0.02
Beans		0.19	0.01	0.5	0.02

Note: Parmal, also known as pointed gourd, is a type of gourd. As gourds are assigned a dependence rate of 0.95, Parmal is assumed to have a dependence rate of 0.95 in this report.

Condiments & spices

5.26 The table 17 shows crop-wise estimates of pollination-attributed value of output of crops (PVO) and the pollination share in crop GVO for selected condiments and spices in 2012-13 and 2021-22, based on their dependence rates (DR).

Table 17: Pollination Contribution to Selected Condiments & Spices Output: PVO and Share in Crop GVO (in ₹ '000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Cardamom	0.95	1.29	0.1	3.91	0.14
Coriander	0.65	1.3	0.1	5.56	0.2
Fennel		0.26	0.02	0.69	0.03
Cumin		3.39	0.25	6.21	0.22
Nutmeg		0.28	0.02	0.32	0.01
Chillies	0.25	2.8	0.21	8.09	0.29
Black pepper	0.05	0.11	0.01	0.22	0.01
Areca nut		0.42	0.03	3.23	0.12
Methi		0.01	0.001	0.04	0.002
Tamarind		0.04	0.003	0.08	0.003

Overall, PVO increases for most crops over the decade, indicating a rising economic contribution of pollination services in this segment. Cumin records the highest PVO in both years, increasing from ₹3.39 to ₹6.21 ('000 crore), although its pollination share declines marginally from 0.25% to 0.22%. Chillies (DR 0.25) show strong growth from ₹2.80 to ₹8.09 (1000 crore), with the pollination share rising from 0.21% to 0.29%. Coriander (DR 0.65) increases from ₹1.30 to ₹5.56 (1000 crore), and its pollination share doubles from 0.10% to 0.20%, while cardamom (DR 0.95) rises from ₹1.29 to ₹3.91 ('000 crore) with the share increasing from 0.10% to 0.14%. A notable increase is also observed for areca nut, which rises from ₹0.42 to ₹3.23 ('000 crore) and from 0.03% to 0.12% in pollination share.

5.27 In comparison, crops such as fennel show moderate increases, whereas low-dependence or smaller crops such as black pepper (DR 0.05), methi, and tamarind remain negligible in both PVO and pollination share. Overall, the table indicates that the pollination-attributable value in condiments and spices increased considerably between 2012-13 and 2021-22, with the largest absolute contributions and growth concentrated in cumin, chillies, coriander, cardamom and areca nut.

Other Pollination dependent Crops

Table 18: Pollination Contribution to Selected Crops Output: PVO and Share in Crop GVO (in ₹ ’000 crores)

18(a) Essential Dependence Crops: PVO and Share in Crop GVO (in ₹ ’000 crores)

Crop	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Cocoa	0.95	0.13	0.01	0.32	0.01

5.28 In table 18(a), Cocoa’s PVO increases from ₹0.13 (1000 crore) in 2012–13 to ₹0.32 (1000 crore) in 2021–22, reflecting growth in the pollination-enabled component of cocoa output over the decade. However, the pollination share in crop GVO remains constant at 0.01% in both years, indicating that while the absolute pollination-attributable value increased, cocoa continues to represent a very small share of total crop output at the aggregate level.

18(b) Great Dependence Crops: PVO and Share in Crop GVO (in ₹ ’000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Rapeseed & mustard	0.65	18.22	1.37	49.44	1.79
Niger seed		0.2	0.02	0.12	0
Sunflower		1.13	0.08	0.9	0.03
Taramira		0.11	0.01	0.68	0.02
Cashew nut		2.93	0.22	5.85	0.21
Almonds		0.08	0.01	0.16	0.01

5.29 The crops presented in table 18(b) belong to two crop categories: oilseeds (rapeseed & mustard, niger seed, sunflower, taramira) and fruits & vegetables (cashew nut and almonds). Within the oilseeds category, rapeseed & mustard contributes the largest pollination-attributable value, increasing from ₹18.22 (’000 crore) in 2012-13 to ₹49.44 (’000 crore) in 2021-22, and its pollination share in crop GVO rises from 1.37% to 1.79%, indicating a strengthened contribution over the period. The remaining oilseeds contribute much smaller values: sunflower declines in PVO and share (0.08% to 0.03%), taramira increases (0.01% to 0.02%), and niger seed remains negligible by 2021-22.

5.30 Within the fruits & vegetables category, cashew nut records a notable increase in PVO from ₹2.93 to ₹5.85 (’000 crore), while its pollination share remains nearly stable (0.22% to 0.21%). Almonds remain small in magnitude, increasing from ₹0.08 to ₹0.16 (’000 crore) with a stable pollination share of 0.01%. Overall, the table indicates that the pollination-attributable contribution is concentrated in rapeseed & mustard among oilseeds and in cashew nut within fruits & vegetables, reflecting differences in underlying output levels across crops.

18(c) Modest Dependence Crops: PVO and Share in Crop GVO (in ₹ '000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Linseed	0.25	0.16	0.01	0.2	0.01
Sesamum		1.02	0.08	1.72	0.06
Castor		1.52	0.11	2.56	0.09
Coconut		2.75	0.21	7.48	0.27
Safflower		0.08	0.01	0.07	0.003
Soyabean		10.19	0.77	19.02	0.69
Kapas		17.13	1.29	29.6	1.07
Sannhemp		0.008	0.001	0.018	0.001
Coffee		1.82	0.14	2.18	0.08
Mulberry		0.01	0.001	0.01	0.001

5.31 The crops in the table 18 (c) are drawn from four crop categories: oilseeds (linseed, sesamum, castor, coconut, safflower, soyabean), fibres (kapas; Sannhemp), drugs & narcotics (coffee), and other crops (mulberry). Within oilseeds, soyabean has the highest pollination-attributable value, rising from ₹10.19 to ₹19.02 ('000 crore), though its pollination share falls slightly (0.77% to 0.69%). Coconut shows strong growth from ₹2.75 to ₹7.48 ('000 crore) and an increased share (0.21% to 0.27%). Sesamum and castor record moderate PVO increases but small declines in share, while linseed remains low and stable (0.01%).

5.32 In the fibres category, kapas registers a large increase in PVO from ₹17.13 ('000 crore) to ₹29.60 ('000 crore), while its pollination share declines from 1.29% to 1.07%, reflecting rapid growth in total output relative to the pollination-attributable component. Sannhemp remains negligible. Coffee increases modestly from ₹1.82 to ₹2.18 ('000 crore), but its share declines from 0.14% to 0.08% while, mulberry remains very small and essentially unchanged. The table indicated that pollination-attributable values increased over the decade for most crops, with the largest absolute contributions concentrated in kapas (fibres) and soyabean (oilseeds), and a notable strengthening in relative contribution for coconut as reflected in its higher share in crop GVO.

18(d) Little Dependence Crops: PVO and Share in Crop GVO (in ₹ '000 crores)

Crops	Dependence Rate	2012-13		2021-22	
		Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)	Pollination-attributed Value of Output (PVO)	Pollination Share in Crop GVO (%)
Arhar	0.05	0.58	0.04	1.28	0.05
Moth		0.05	0.004	0.06	0.002
Rajma		0.004	0.0003	0.01	0.0005
Cowpea		0.01	0.001	0.02	0.001
Urd		0.35	0.03	0.86	0.03
Moong		0.26	0.02	0.96	0.03
Groundnut		1.02	0.08	2.86	0.1
Opium		0.003	0.0002	0.003	0.0001

5.33 The crops covered in table 18(d) fall into three crop categories: pulses (arhar, moth, rajma, cowpea, urd and moong), oilseeds (groundnut), and drugs & narcotics (opium).

Within pulses, arhar contributes the highest pollination-attributable value, rising from ₹0.58 to ₹1.28 ('000 crore), with its share increasing slightly (0.04% to 0.05%). Most other pulses remain small: moth increases marginally but its share declines (0.004% to 0.002%), while rajma and cowpea stay negligible despite minor gains by 2021-22. In contrast, urd and moong show notable growth in PVO (₹0.35 to ₹0.86 and ₹0.26 to ₹0.96 ('000 crore)), with both reaching a 0.03% pollination share in 2021-22.

5.34 Groundnut shows a clear rise in pollination-attributable value from ₹1.02 to ₹2.86 ('000 crore), with its pollination share increasing slightly from 0.08% to 0.10%, indicating a modest strengthening over time. In contrast, opium remains negligible, with PVO unchanged at ₹0.003 and an extremely small pollination share that declines marginally. The table indicates that pollination-attributable values remain relatively small across pulses and related crops, but increases are visible over time, with groundnut and arhar contributing the largest PVO values in their respective categories.

Supply-Use Table (Monetary) for Crop-Pollination services

5.35 The Supply-Use Tables framework, adapted from the System of Environmental-Economic Accounting (SEEA), provides a structured approach to account for pollination ecosystem services within national accounting systems. This framework integrates pollination services into the standard accounting structure used for national economic statistics, enabling formal recognition of pollinators' contribution to national wealth and economic production.

Table 19a: Monetary Supply Tables for Pollination services for 2012-13 and 2021-22

SUPPLY	Ecosystem services (reference list)		ES: Pollination services	ES: Pollination services
	Measurement unit		₹ ’000 crore (2012-13)	₹ ’000 crore (2021-22)
Economic units	Industries	Agriculture		
		…….		
		Other industries		
	Total Industry			
	Government consumption			
	Household consumption			
	Total supply by resident economic units			
	Supply by non-resident economic units – Imports			
Total supply by economic units				
Ecosystem type	Terrestrial	Forest	-	-
		Croplands	115.22	265.86
		Grasslands	-	-
	Freshwater			
	Marine		-	-
Total supply by resident ecosystem assets			-	-
Supply from non-resident ecosystem assets – Imports			-	-
Total supply by ecosystem assets			-	-
TOTAL SUPPLY			115.22	265.86

Table 19b: Monetary Use Tables for Pollination services for 2012-13 and 2021-22

USE	Ecosystem services (reference list)		ES: Pollination services	ES: Pollination services
	Measurement unit		₹ ’000 crore (2012-13)	₹ ’000 crore (2021-22)
Economic units	Industries	Agriculture	115.22	265.86
		…….	-	-
		Other industries	-	-
	Total Industry		-	-
	Government consumption		-	-
	Household consumption		-	-
	Total use by resident economic units		-	-
	Exports – Final Ecosystem Services		-	-
Total use by economic units			-	-
Ecosystem type	Terrestrial	Forest		
		Croplands		
		Grasslands		
	Freshwater			
	Marine			
Total use by resident ecosystem assets			-	-
Exports – intermediate services			-	-
Total use by ecosystem assets			-	-
TOTAL USE			115.22	265.86

5.36 The table 19 presents the Monetary Supply and Use Table (MSUT) within an ecosystem services supply-use framework for 2012-13 and 2021-22. In line with the SEEA accounting principles, the table records ecosystem services in monetary terms to make the contribution of ecosystem assets visible in relation to economic activity and beneficiary sectors. Such valuation supports policy relevance by highlighting the economic importance of ecological processes like pollination.

5.37 On the supply side, ecosystem assets supply services such as pollination, and in this table, the supply is attributed to cropland (ecosystem asset type). The monetary supply is reported as ₹ 115.22 '000 crore in 2012-13 and increases to ₹ 265.86 '000 crore in 2021-22, indicating a substantial rise in the value of pollination services generated by cropland ecosystems over the period. On the use side, the table shows that the corresponding value of pollination services is used entirely by the Agriculture economic sector, reflecting agriculture as the primary beneficiary of pollination services. Since, from agriculture sector it is further supplied to other economic sector such as households, industries, etc. The supply and use values match for each year (i.e., supply equals use), which is consistent with the accounting identity in ecosystem services supply–use tables, ensuring that the ecosystem service flow is fully allocated from the supplying ecosystem asset to the using economic unit.

5.38 In the present MSUT, the monetary supply of pollination services is attributed only to cropland ecosystem, and the potential contributions of other ecosystem asset types-such as forests and grasslands-have not been incorporated on the supply side. On the use side, the monetary value of pollination services is allocated entirely to the agriculture sector, since, under the current System of National Accounts (SNA) reporting structure, the value of output for the relevant pollination-dependent crops is recorded within the aggregate industry group "Agriculture, Forestry and Fishing." Subject to data availability and classification refinements, this allocation can be extended in future work by disaggregating the use of pollination services across more detailed industry groups and, where appropriate, by distinguishing the share attributable to household production activities.

Chapter- 6
Policy Relevance of Pollination Services

Policy Relevance

6.1 It is crucial to maintain a balance between productivity-enhancing inputs (such as irrigation, fertiliser, pesticides, and improved varieties) and biological enablers of yield (such as animal-mediated pollination). If pollination-support is too weak, the production system may show lower flowering-to-fruit set, reduced quality, and higher yield variability-especially in crops where pollination is a binding constraint. Conversely, if production intensification is pursued without pollinator-safe practices, the system may experience pollinator stress and a gradual erosion of the very ecosystem function that sustains output in pollination-dependent crops. Within this framing, the economic valuation of crop pollination services provides a quantitative basis to justify public programmes that strengthen pollinator populations (managed and wild) and the broader beekeeping value chain. The Government of India has perceive pollination services and beekeeping as critical sectors requiring dedicated policy intervention and substantial financial support. Multiple policy instruments have been introduced across agriculture, biodiversity conservation, and rural development domains that directly and indirectly support pollinator populations and pollination services, backed by dedicated budgetary allocations reflecting government commitment to this critical ecosystem service.

6.2 In India, public support for beekeeping and pollination has been channelled through horticulture missions and beekeeping-focused initiatives, most notably through the National Bee Board (NBB) and, since 2020–21, the National Beekeeping & Honey Mission (NBHM).

6.3 The National Beekeeping and Honey Mission (NBHM), implemented through the Ministry of Agriculture and Farmers Welfare. This central sector scheme has been allocated ₹500 crore over 2020-21 to 2025-26, representing the largest sustained central government budgetary commitment to beekeeping and pollination services in India's history. The scheme supports managed beekeeping development through capacity building, farmer training, equipment support, honey processing infrastructure, and market linkage development. The NBHM is being implemented through 3 Mini Missions (MMs) - MM-I, MM-II & MM- III:

a) Mini Mission-I: Under this Mission, thrust will be given on production & productivity improvement of various crops through pollination assisted by adoption of scientific beekeeping;

b) Mini Mission-II: This Mission will concentrate on post-harvest management of beekeeping/beehive products including collection, processing, storage, marketing, value addition, etc. with a thrust to develop requisite infrastructural facilities for these activities; and

c) Mini Mission-III: This Mission will concentrate on research & technology generation for different regions/states/agro-climatic and socio-economic conditions.

6.4 Another Centrally Sponsored Scheme of Ministry of Agriculture and farmers welfare covers pollination related component is the Mission for Integrated Development of Horticulture (MIDH) which being implemented since 2014-15 for the holistic development of the horticulture sector in the country. The scheme covers a wide range of crops, including fruits, vegetables, root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, and cocoa, and is operational across all States and Union Territories.

6.5 Under MIDH, financial and technical assistance is provided to States/UTs for various interventions, including beekeeping for pollination. Support is extended for activities such as production of nucleus stock, production of bee colonies by bee breeders, and provision of bee hives/boxes with bee colonies, complete beekeeping equipment, and related infrastructure to promote effective pollination services and enhance horticultural productivity.

6.6 The Khadi and Village Industries Commission (KVIC) also launched the Honey (Bee) Mission in July 2017 to promote beekeeping and generate employment in states with high beekeeping potential. The mission is implemented by the Khadi and Village Industries Commission (KVIC) under the Ministry of Micro, Small and Medium Enterprises (MSME) as part of the Agro-Based and Food Processing Industries (ABFPI) component of the Gramodyog Vikas Yojana (GVY). The mission supports a range of activities, including financial assistance for beekeeping, training and capacity building, and distribution of toolkits and equipment to beneficiaries. It also provides training for KVIC officers and staff at CBRTI, Pune, advanced training for previously trained beneficiaries, awareness programmes, and state-level beekeepers' meets under the Honey Mission.

6.7 The public-finance relevance becomes clearer when the valuation of pollination services reported in this report is compared alongside funds released for beekeeping/pollination support through MIDH/ NBHM/ RKVY, DAC&FW/ KVIC, MSME/Ministry of Tribal Affairs as shown in table 20 and figure 14.

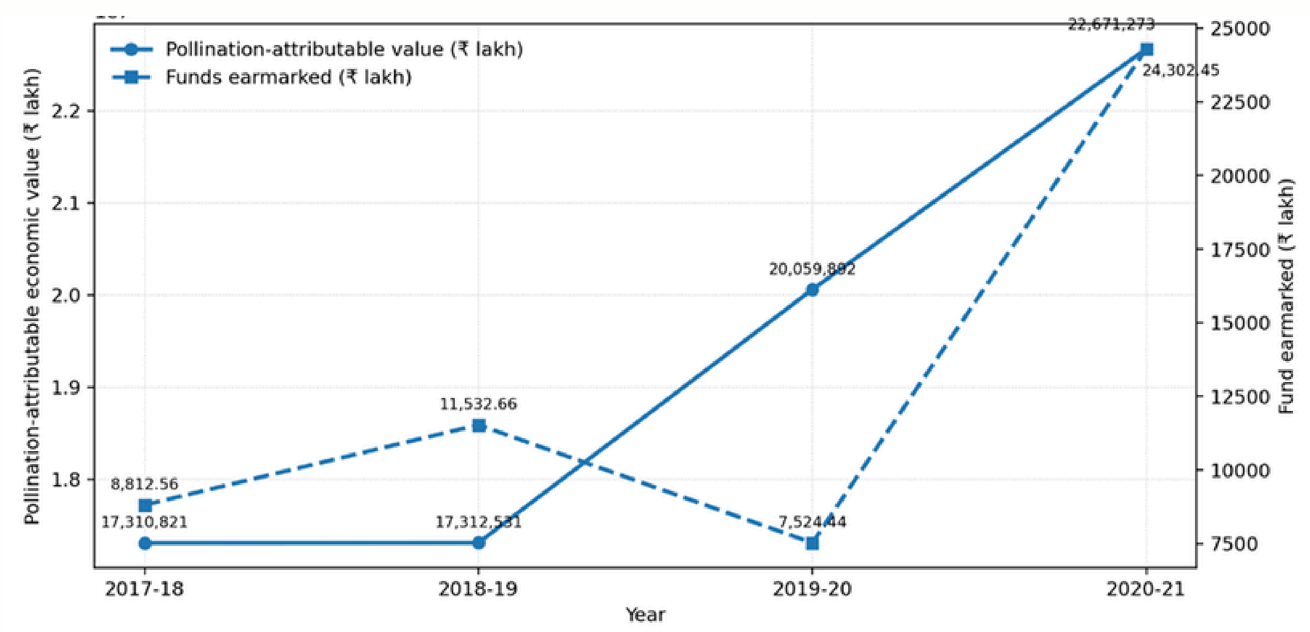
Table 20: Pollination-attributed value of output of crops (PVO) and funds earmarked for beekeeping/pollination support (₹ lakh)

Year	pollination attributed economic value of output (crops)	Fund Earmarked under MIDH/ NBHM/ RKVY, DAC&FW/ KVIC, MSME/Ministry of Tribal Affairs [32]
2017-18	17310821	8812.56
2018-19	17312531	11532.66
2019-20	20059892	7524.44
2020-21	22671273	24302.45

Note 1: The fund-earmarked figures presented in the chart are not exhaustive. They are included to highlight the policy relevance and importance of beekeeping and pollination-support interventions on PVO.

Note 2 : Fund Earmarked is different from actual expenditure.

Figure 14: Pollination attributable economic value of output and Beekeeping/pollination support funds (2017-18 to 2020-21)



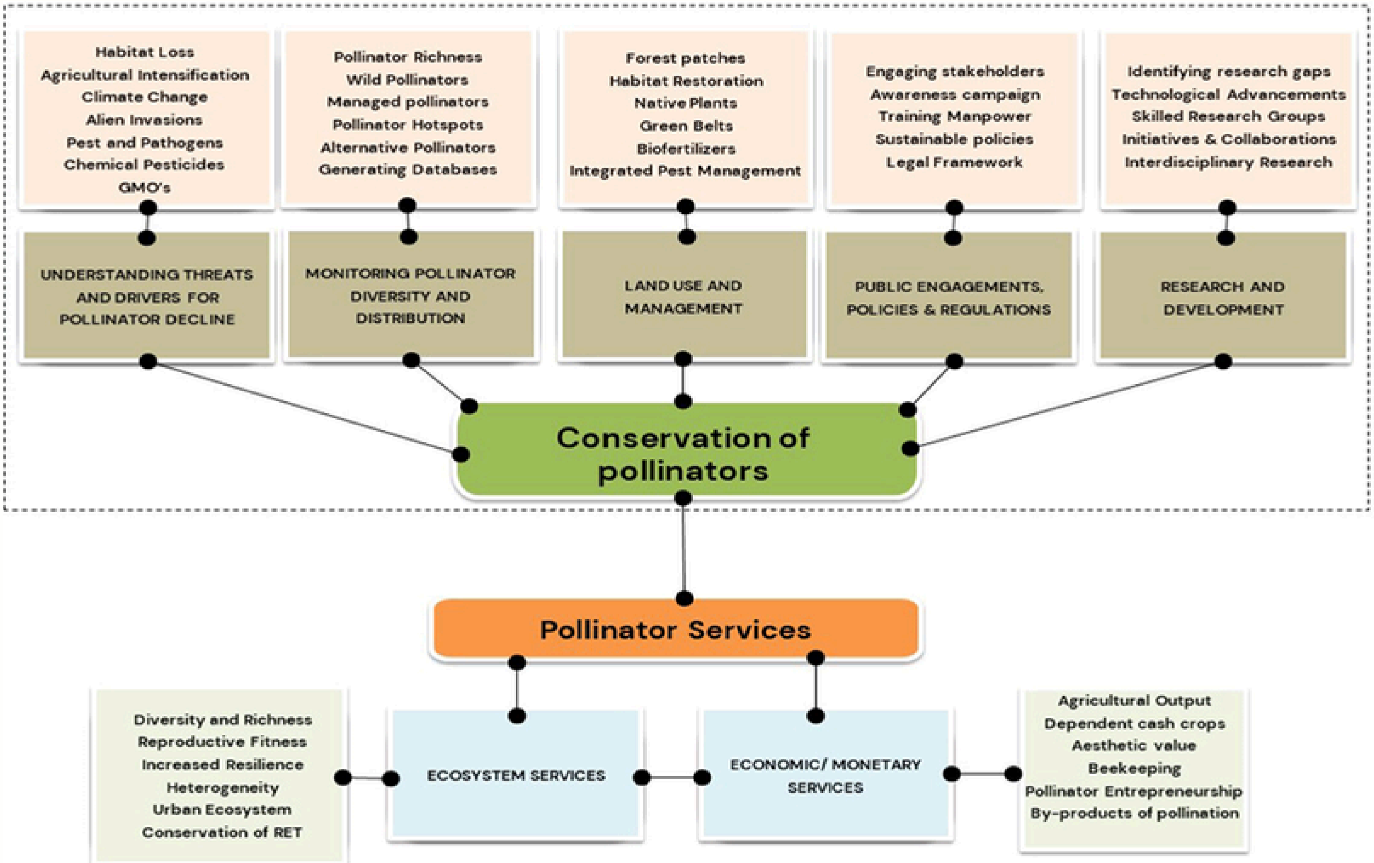
[32] https://sansad.in/getFile/annex/252/AU658.pdf?source=pqars#:~:text=S.%20N.-,Year%20Funds%20earmarked%20(Rs.,under%20the%20scheme%20are%2018%2C635.

Note: The beekeeping and pollination-support funds are primarily directed towards the promotion of managed bee-based activities and associated co-benefits (such as apiculture development and related livelihood support). While these interventions are not designed exclusively as pollination-specific measures, they are likely to generate indirect gains in crop pollination services through improved availability and management of domesticated pollinators. However, the scope of these earmarked funds does not explicitly extend to the conservation and protection of wild pollinators (including wild bees) or other non-bee pollinator groups, which remain largely outside the funding focus reflected in this figure.

6.8 The table 20 and figure 14 indicate that public programmes for beekeeping/pollination support are not only livelihood schemes but also productivity-enhancing interventions. Funds earmarked under MIDH/NBHM and allied programmes support employment and enterprise creation through apiary establishment, training, equipment, processing and marketing, which translate into higher honey and other hive-product generation and stronger rural value chains. At the same time, strengthened beekeeping increases the availability of managed pollinators during crop flowering, thereby improving fruit/seed set, quality and yield stability. Even from these limited values, it is clear that the environment provides benefits far greater than the investments made in it. While public spending and human efforts are focused on only a few environmental sectors, the ecosystem services received in return are almost 1,000 times more than the money spent or efforts made. Overall, the evidence supports the policy rationale that beekeeping investments deliver direct income gains (honey and allied products) while also providing a large indirect economic return through enhanced pollination services reflected in crop output.

6.9 The effectiveness of beekeeping and pollination missions, however, depends on whether landscapes retain the ecological infrastructure that pollinators require. In this context, forest and biodiversity policies function as enabling conditions for pollination outcomes because forests and protected landscapes provide forage diversity, nesting substrates, and habitat continuity that sustain wild pollinator populations and strengthen resilience in agricultural mosaics as shown in figure 15.

Figure 15: Priorities and roadmap for pollinator conservation in India based on the ecosystem services provided by them[36]



6.10 Beyond direct support for beekeeping, the Government also implements schemes focused on habitat protection and restoration, which indirectly benefit pollinator populations. The Ministry of Environment, Forest and Climate Change (MoEFCC) implements plantation and afforestation programmes in forest areas through a participatory approach. The Ministry's major schemes for forest development include the National Afforestation Programme (NAP), the National Mission for a Green India (GIM), and the Forest Fire Prevention and Management (FFPM) Scheme.

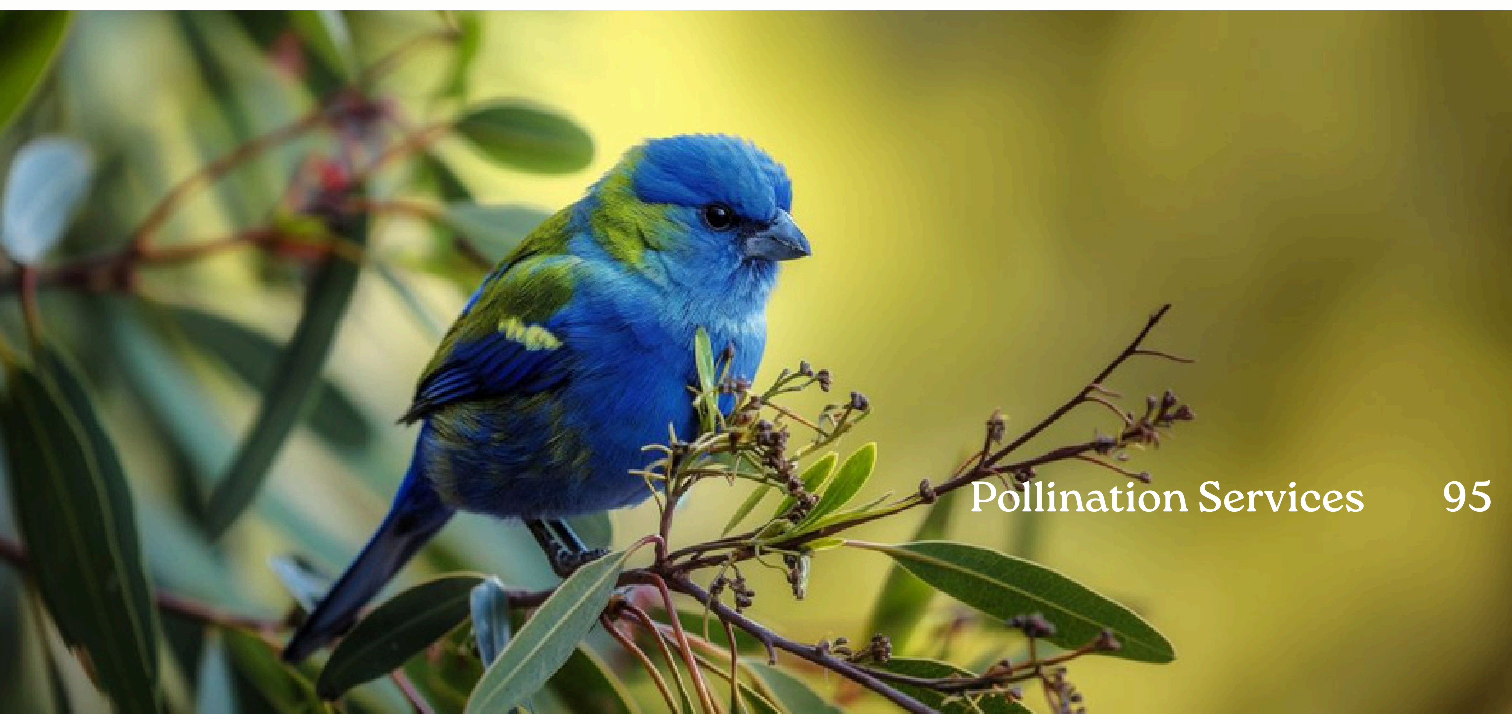
6.11 The National Afforestation Programme focuses on afforestation and ecological restoration of degraded forest lands, with an emphasis on people's participation and livelihood improvement of forest-fringe communities, particularly the poor. The Green India Mission aims to improve forest quality and enhance forest and tree cover through a landscape-based, cross-sectoral approach. The Forest Fire Prevention and Management Scheme addresses forest fire prevention and management measures to protect forest ecosystems.

[36] Arjun Adit, Singh, V. K., Tandon, R., & Kundaranahalli Ramalingaiah Shivanna. (2024). Pollination research in India: Current status, future vision and conservation implications. Integrative Conservation. .https://doi.org/10.1002/inc3.74.

6.12 It is pertinent to recognise that the long-term success of the Government of India's Green India Mission and broader ecological restoration efforts on degraded lands is closely linked to the continuation of functional pollination services provided by diverse fauna as afforestation and pollination both are inter-dependent. Many native tree, shrub and herb species depend-fully or partly-on animal-mediated pollination for successful flowering, seed set and natural regeneration. Wild bees and other insects, along with birds and bats in specific ecosystems, help maintain genetic diversity and support the establishment of self-sustaining plant populations, which in turn improves ecosystem stability and resilience to climate and other stresses. Accordingly, restoration planning that incorporates pollinator-friendly actions-such as use of native flowering species, habitat heterogeneity, and reduced pressures on pollinator habitats-can strengthen survival and regeneration outcomes and enhance the durability of afforestation and restoration gains over time.

6.13 NAP is implemented through a three-tier institutional framework comprising the State Forest Development Agency (SFDA) at the state level, the Forest Development Agency (FDA) at the forest division level, and Joint Forest Management Committees (JFMCs) at the village level. Collectively, these initiatives contribute to habitat conservation, thereby supporting pollinator populations and strengthening ecosystem resilience.

6.14 Overall, India's policy response to pollination services-implemented through multiple instruments across several ministries and supported by sustained fiscal commitment-reflects recognition of pollination as essential for agricultural productivity, food security, rural livelihoods, and ecosystem stability. Continued, coordinated multi-ministerial support remains critical for conserving pollinators, sustaining agricultural production, and advancing long-term sustainable development objectives.



Way Forward

6.15 The pollination services estimate in the present publication represent an initial ecosystem accounting effort to quantify the pollination-attributed value of output (PVO) for selected crops; however, the current compilation is subject to certain limitations. The publication could not statistically isolate productivity changes specifically attributable to pollinator loss/decline because time-varying, regionally consistent pollinator datasets and a counterfactual basis for attribution are not available, and therefore this refinement could not be included in the present round. Further, analytical extensions such as estimating the contribution of cross-pollinated crops to aggregate food and nutritional security outcomes could not be taken up because they require additional datasets and a dedicated methodological treatment beyond the scope and data readiness of the current release.

6.16 Going forward, the accounting framework may be progressively through strengthening pollination estimates by moving from uniform, literature-based dependence rates to India-specific, crop- and region-sensitive coefficients grounded in primary evidence and local agronomic conditions. . To the extent feasible and consistent with SEEA framework applications, the inclusion of uncertainty through sensitivity analysis will also be explored. In addition, over the medium term, subject to feasibility, examine benchmarking and validation approaches-including field verification and/or the integration of relevant pollinator modules within dedicated studies or surveys-will be attempted. The integration of pollinator-related modules and proxies into surveys or studies (such as information on managed pollination use, pollinator presence/abundance indicators, and habitat/forage conditions) would enable systematic compilation of spatially disaggregated estimates and better tracking of trends. Meanwhile, the scope of valuation could be widened by explicitly listing currently excluded crops and expanding coverage as Value of Output and dependence information become available, thereby improving completeness and comparability of the ecosystem service account. MoSPI will also endeavour to extend PVO estimates to the latest available years, subject to availability of aligned and updated dependence-rate coefficients and consistent crop statistics, and will examine alternative price data sources for suitability and comparability within the adopted valuation approach. To improve accessibility and policy usability, chapter-wise executive summaries may be incorporated, and the scope of valuation may be explored to include pollination services in natural ecosystems (including forests) in a dedicated section based on methodology availability in future releases.

6.17 The present publication is largely compiled at the national scale and therefore does not provide state/agro-ecological zone-wise disaggregation, which limits the policy relevance of the estimates and constrains interpretation of how state-specific initiatives may influence pollinator-friendly practices, production systems, and pollination outcomes. Going forward, in the next publication, the attempt to compile pollination service valuation estimates at the state level will be explored, thereby enabling more granular and targeted valuation outputs beyond the national aggregates.

Annexure- I

Pollination attributed value of output at Current Price (in ₹ ’000 crores)

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Rapeseed & mustard	0.65	18.22	16.29	14.14	16.94	18.47	21.55	23.53	25.19	38.53	49.44
Niger seed		0.2	0.21	0.18	0.21	0.26	0.2	0.14	0.14	0.15	0.12
Sunflower		1.13	1.03	0.89	0.64	0.52	0.43	0.47	0.54	0.69	0.9
Taramira		0.11	0.3	0.04	0.02	0.28	0.05	0.1	0.99	0.21	0.68
Linseed	0.25	0.16	0.13	0.15	0.12	0.2	0.19	0.11	0.15	0.16	0.2
Sesamum		1.02	1.49	1.57	1.3	1.12	1.18	1.4	1.53	1.81	1.72
Castor		1.52	1.57	1.77	1.46	1.33	1.79	1.52	1.99	1.84	2.56
Coconut		2.75	3.66	5.36	5.07	4.26	5.64	6.17	6.16	7.39	7.48
Safflower		0.08	0.08	0.05	0.04	0.06	0.04	0.02	0.04	0.04	0.07
Soyabean		10.19	10.33	9.14	7.83	10.16	8.5	10.95	10.35	12.55	19.02
Groundnut	0.05	1.02	1.78	1.48	1.51	1.81	2.17	1.55	2.47	2.69	2.86
Pumpkin	0.95	0.31	0.35	1.25	1.72	1.82	2	2.57	3.09	3.09	3.42
Watermelon		2.66	3.2	3.81	4.17	3.91	4.34	3.58	4.68	4.93	5.39
Parmal		0.25	0.32	0.64	0.47	0.56	0.68	2.07	2.78	2.45	2.68
Muskmelon		0.66	0.69	0.73	1.23	1.3	1.99	1.63	1.86	2.27	2.23
Bitter gourd		1.51	1.47	1.66	2.1	2.24	2.35	2.66	3.35	3.37	4.33
Bottle gourd		1.47	1.67	1.78	1.99	2.05	2.42	2.79	3.68	4.06	4.69

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Cashew nut		2.93	3.78	4.47	4.64	5.21	5.63	5.1	4.79	5	5.85
Apple		4.16	4.92	4.25	4.51	4.2	4.54	4.36	5.9	5.04	6.82
Mosambi		1.02	1.42	1.28	1.36	1.53	1.63	1.55	1.68	1.52	1.76
Cherry		0.03	0.04	0.06	0.07	0.04	0.03	0.04	0.05	0.09	0.1
Almonds		0.08	0.11	0.09	0.08	0.07	0.14	0.12	0.14	0.15	0.16
Pear	**0.65**	0.48	0.49	0.58	0.53	0.57	0.42	0.46	0.51	0.63	0.71
Guava		2.52	3.71	4.61	4.85	4.99	5.9	6.58	7.16	7.54	9.76
Peach/ plum		0.45	0.45	0.28	0.32	0.35	0.41	0.36	0.49	0.55	0.61
Strawberry		0	0	0.03	0.01	0.01	0.01	0.01	0.01	0.04	0.03
Tomato		13.54	17.76	16.99	20.71	21.06	27.68	22.82	29.12	31.36	32.22
Cucumber		0.4	0.47	0.54	0.8	0.78	0.84	1.51	1.57	1.62	1.88
Orange		2.87	3.3	3.73	3.86	4.42	5.17	5.81	6.25	6.72	9.57
Lichi		0.64	0.61	0.65	0.71	0.76	0.89	0.88	0.92	0.92	1.01
Ber		0.15	0.24	0.16	0.17	0.22	0.24	0.28	0.36	0.36	0.32
Pomegranate	**0.25**	0.54	0.99	1.43	2.36	2.47	2.73	2.98	3.36	4.03	3.86
Okra		2.84	3.19	3.14	3.09	3.42	4.11	4.17	4.01	4.28	5.21
Brinjal		4.95	5.87	5.45	5.54	5.54	6.77	6.7	7.54	7.97	7.99

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Sweet potato	0.05	0.08	0.09	0.1	0.1	0.11	0.13	0.13	0.15	0.12	0.13
Mango		2.09	2.09	2.69	2.88	3.14	3.66	3.81	3.99	4.24	4.55
Papaya		0.31	0.38	0.34	0.4	0.46	0.47	0.55	0.57	0.58	0.63
Lemon		0.25	0.29	0.41	0.39	0.38	0.43	0.52	0.51	0.53	0.68
Other citrus fruit		0.06	0.07	0.09	0.08	0.11	0.1	0.04	0.05	0.03	0.05
Capsicum		0.02	0.01	0.02	0.03	0.03	0.03	0.08	0.09	0.1	0.11
Beans		0.19	0.23	0.29	0.34	0.31	0.34	0.38	0.44	0.47	0.5
Potato	0	0	0	0	0	0	0	0	0	0	0
Banana		0	0	0	0	0	0	0	0	0	0
Tapioca		0	0	0	0	0	0	0	0	0	0
Onion		0	0	0	0	0	0	0	0	0	0
Grapes		0	0	0	0	0	0	0	0	0	0
Pine apple		0	0	0	0	0	0	0	0	0	0
Cabbage		0	0	0	0	0	0	0	0	0	0
Cauliflower		0	0	0	0	0	0	0	0	0	0
Green peas		0	0	0	0	0	0	0	0	0	0
Carrot		0	0	0	0	0	0	0	0	0	0
Radish		0	0	0	0	0	0	0	0	0	0

<table>
<tr><th>Crops</th><th>Dependence Rate</th><th>2012-13</th><th>2013-14</th><th>2014-15</th><th>2015-16</th><th>2016-17</th><th>2017-18</th><th>2018-19</th><th>2019-20</th><th>2020-21</th><th>2021-22</th></tr>
<tr><td>Arhar</td><td rowspan="6">0.05</td><td>0.58</td><td>0.65</td><td>0.74</td><td>0.99</td><td>1.44</td><td>1.01</td><td>0.82</td><td>1.03</td><td>1.31</td><td>1.28</td></tr>
<tr><td>Urd</td><td>0.35</td><td>0.36</td><td>0.52</td><td>0.78</td><td>1.02</td><td>0.94</td><td>0.76</td><td>0.61</td><td>0.76</td><td>0.86</td></tr>
<tr><td>Moong</td><td>0.26</td><td>0.41</td><td>0.47</td><td>0.53</td><td>0.63</td><td>0.51</td><td>0.65</td><td>0.79</td><td>1</td><td>0.96</td></tr>
<tr><td>Moth</td><td>0.05</td><td>0.06</td><td>0.09</td><td>0.09</td><td>0.15</td><td>0.08</td><td>0.05</td><td>0.08</td><td>0.09</td><td>0.06</td></tr>
<tr><td>Rajma</td><td>0</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td></tr>
<tr><td>Cowpea</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.01</td><td>0.02</td><td>0.02</td></tr>
<tr><td>Chola</td><td rowspan="4">0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Peas/Chawali</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Gram</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Masoor</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Cardamom</td><td>0.95</td><td>1.29</td><td>1.37</td><td>1.92</td><td>1.76</td><td>2.36</td><td>2.54</td><td>2.09</td><td>3.5</td><td>4.04</td><td>3.91</td></tr>
<tr><td>Coriander</td><td rowspan="4">0.65</td><td>1.3</td><td>1.29</td><td>2.11</td><td>2.69</td><td>3.1</td><td>2.41</td><td>2.15</td><td>3.82</td><td>5.41</td><td>5.56</td></tr>
<tr><td>Fennel</td><td>0.26</td><td>0.32</td><td>0.33</td><td>0.63</td><td>0.75</td><td>0.48</td><td>0.78</td><td>0.53</td><td>0.54</td><td>0.69</td></tr>
<tr><td>Cumin</td><td>3.39</td><td>3.53</td><td>3.52</td><td>4.53</td><td>4.88</td><td>7.16</td><td>6.93</td><td>8.05</td><td>6.63</td><td>6.21</td></tr>
<tr><td>Nutmeg</td><td>0.28</td><td>0.26</td><td>0.25</td><td>0.22</td><td>0.19</td><td>0.18</td><td>0.19</td><td>0.2</td><td>0.22</td><td>0.32</td></tr>
<tr><td>Chillies</td><td>0.25</td><td>2.8</td><td>4.1</td><td>4.81</td><td>4.33</td><td>5.52</td><td>5.48</td><td>4.93</td><td>5.93</td><td>8.22</td><td>8.09</td></tr>
</table>

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Black Pepper	0.05	0.11	0.1	0.19	0.21	0.19	0.14	0.11	0.16	0.24	0.22
Methi		0.01	0.01	0.03	0.06	0.05	0.03	0.02	0.02	0.04	0.04
Tamarind		0.04	0.05	0.07	0.07	0.07	0.08	0.09	0.09	0.1	0.08
Areca Nut		0.42	0.51	0.73	0.83	0.77	1.15	1.43	1.69	2.5	3.23
Garlic	0	0	0	0	0	0	0	0	0	0	0
Dry Ginger		0	0	0	0	0	0	0	0	0	0
Turmeric		0	0	0	0	0	0	0	0	0	0
Cloves		0	0	0	0	0	0	0	0	0	0
Other Condiments And Spices		0	0	0	0	0	0	0	0	0	0
Kapas	0.25	17.13	20.63	17.69	15.79	20.55	20.3	18.87	23.46	23.37	29.6
Sannhemp		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Mesta	0	0	0	0	0	0	0	0	0	0	0
Jute		0	0	0	0	0	0	0	0	0	0
Cocoa	0.95	0.13	0.13	0.28	0.49	0.4	0.43	0.45	0.28	0.31	0.32
Coffee	0.25	1.82	1.69	2.15	1.84	2.09	2.08	2.15	1.74	1.95	2.18
Opium	0.05	0	0	0	0	0	0	0	0	0	0
Tea	0	0	0	0	0	0	0	0	0	0	0
Tobacco Leaf		0	0	0	0	0	0	0	0	0	0
Tobacco Stem		0	0	0	0	0	0	0	0	0	0

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Mulberry	**0.25**	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Guar Seed	**0.05**	1.27	1.51	1.11	0.85	0.55	0.5	0.42	0.29	0.24	0.33
Rubber	**0**	0	0	0	0	0	0	0	0	0	0
Mushroom		0	0	0	0	0	0	0	0	0	0
Paddy	**0**	0	0	0	0	0	0	0	0	0	0
Wheat		0	0	0	0	0	0	0	0	0	0
Bajra		0	0	0	0	0	0	0	0	0	0
Barley		0	0	0	0	0	0	0	0	0	0
Maize		0	0	0	0	0	0	0	0	0	0
Ragi		0	0	0	0	0	0	0	0	0	0
Small Millets		0	0	0	0	0	0	0	0	0	0
Sugarcane	**0**	0	0	0	0	0	0	0	0	0	0
Other Sugars		0	0	0	0	0	0	0	0	0	0
Total		**115.41**	**132.13**	**133.38**	**141.34**	**155.29**	**173.4**	**173.43**	**200.98**	**227.15**	**266.33**

Annexure- II

Pollination attributed value of output at 2011-12 Price (in ₹ ’000 crores)

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Rapeseed & mustard	0.65	17.21	16.09	12.98	14.17	16.27	17.52	19.29	19.03	21.26	24.9
Niger seed		0.19	0.18	0.14	0.13	0.15	0.13	0.09	0.08	0.08	0.06
Sunflower		0.98	0.91	0.78	0.53	0.44	0.39	0.36	0.38	0.41	0.46
Taramira		0.1	0.3	0.03	0.01	0.19	0.03	0.07	0.78	0.11	0.34
Linseed	0.25	0.13	0.1	0.11	0.09	0.13	0.12	0.07	0.08	0.08	0.09
Sesamum		0.72	0.75	0.87	0.9	0.78	0.77	0.7	0.71	0.86	0.83
Castor		2.37	2.07	2.27	2.16	1.7	1.98	1.46	2.24	2.04	2.06
Coconut		3.15	2.95	3.07	3.19	2.84	2.72	2.89	2.95	3.08	3.29
Safflower		0.07	0.07	0.05	0.04	0.06	0.04	0.02	0.03	0.02	0.04
Soyabean		8.33	6.75	5.86	4.85	7.47	6.22	7.54	6.37	7.22	7.39
Groundnut	0.05	0.81	1.72	1.29	1.17	1.29	1.63	1.16	1.74	1.77	1.75

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Pumpkin		0.3	0.27	0.96	1.42	1.43	1.46	1.82	1.93	1.89	2.04
Watermelon		2.59	2.62	2.77	3.58	3.23	3.84	3.43	4.44	4.43	4.7
Parmal		0.22	0.23	0.45	0.31	0.34	0.39	0.79	0.78	0.76	0.79
Muskmelon	0.95	0.68	0.6	0.64	0.79	0.92	1.06	1	1.08	1.13	1.12
Bitter gourd		1.38	1.21	1.18	1.44	1.44	1.62	1.75	1.82	1.94	2.03
Bottle gourd		1.54	1.31	1.3	1.45	1.51	1.67	1.89	1.98	2.06	2.12
Cashew nut		2.89	3.32	3.48	3.16	3.34	3.38	3.2	3.14	3.2	3.41
Apple		2.52	3.47	3.09	3.43	2.53	2.5	2.31	3.42	2.59	3.08
Mosambi		1.08	1.32	1.1	1.11	1.13	1.32	1.24	1.29	1.24	1.22
Cherry		0.04	0.05	0.04	0.04	0.03	0.04	0.05	0.06	0.07	0.08
Almonds		0.08	0.11	0.08	0.07	0.06	0.11	0.09	0.09	0.09	0.1
Pear	0.65	0.46	0.46	0.45	0.45	0.44	0.42	0.4	0.41	0.39	0.44
Guava		2.32	2.6	2.78	2.8	2.71	2.89	3	3.04	3.16	3.68
Peach/ plum		0.4	0.37	0.37	0.43	0.41	0.44	0.43	0.42	0.42	0.43
Strawberry		0	0.01	0.02	0.01	0	0	0	0	0.04	0.02
Tomato		13.08	13.23	11.88	13.5	14.63	14.19	13.74	15.11	15.29	14.93
Cucumber		0.39	0.37	0.38	0.55	0.49	0.53	0.76	0.76	0.78	0.84

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Orange	**0.25**	2.85	3.19	3.25	3.26	3.48	3.87	4.25	4.47	4.53	4.6
Lichi		0.6	0.61	0.57	0.56	0.58	0.67	0.71	0.7	0.71	0.72
Ber		0.17	0.24	0.15	0.16	0.2	0.19	0.2	0.22	0.21	0.2
Pomegranate		0.57	0.86	1.18	1.55	1.8	1.97	2.03	2.43	2.48	2.39
Okra		2.69	2.61	2.43	2.47	2.48	2.54	2.57	2.62	2.67	2.83
Brinjal		4.33	4.42	4.14	4.13	4.15	4.22	4.19	4.21	4.25	4.27
Sweet potato	**0.05**	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.06	0.07
Mango		1.88	1.96	1.96	1.93	2.06	2.2	2.2	2.05	2.1	2.14
Papaya		0.24	0.26	0.25	0.26	0.27	0.27	0.27	0.26	0.25	0.27
Lemon		0.26	0.27	0.31	0.3	0.3	0.33	0.36	0.38	0.37	0.41
Other citrus fruit		0.05	0.05	0.06	0.06	0.08	0.07	0.03	0.03	0.02	0.03
Capsicum		0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.04	0.04
Beans		0.16	0.17	0.22	0.23	0.19	0.22	0.23	0.22	0.24	0.26
Potato	**0**	0	0	0	0	0	0	0	0	0	0
Banana		0	0	0	0	0	0	0	0	0	0
Tapioca		0	0	0	0	0	0	0	0	0	0

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Onion		0	0	0	0	0	0	0	0	0	0
Grapes		0	0	0	0	0	0	0	0	0	0
Pineapple		0	0	0	0	0	0	0	0	0	0
Cabbage		0	0	0	0	0	0	0	0	0	0
Cauliflower		0	0	0	0	0	0	0	0	0	0
Green peas		0	0	0	0	0	0	0	0	0	0
Carrot		0	0	0	0	0	0	0	0	0	0
Radish		0	0	0	0	0	0	0	0	0	0
Arhar	0.05	0.51	0.53	0.47	0.43	0.81	0.72	0.56	0.65	0.72	0.71
Urd		0.34	0.3	0.34	0.34	0.48	0.56	0.5	0.36	0.38	0.47
Moong		0.22	0.3	0.28	0.3	0.4	0.37	0.44	0.45	0.55	0.56
Moth		0.03	0.03	0.04	0.03	0.05	0.04	0.02	0.03	0.03	0.02
Rajma		0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0
Cowpea		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Chola	0	0	0	0	0	0	0	0	0	0	0
Peas/Chawali		0	0	0	0	0	0	0	0	0	0
Gram		0	0	0	0	0	0	0	0	0	0
Masoor		0	0	0	0	0	0	0	0	0	0
Cardamom	0.95	1.18	1.41	1.59	1.68	1.66	1.7	1.25	1.14	1.92	2.1
Coriander	0.65	1.03	0.81	1.17	1.6	2.6	2.09	1.69	2.1	2.67	2.29
Fennel		0.24	0.23	0.22	0.42	0.49	0.33	0.5	0.44	0.44	0.36
Cumin		3.97	4.39	4.26	4.32	4.21	5.88	5.9	7.76	6.82	4.76
Nutmeg		0.27	0.29	0.31	0.33	0.3	0.33	0.33	0.34	0.33	0.39
Chillies	0.25	2.9	3.6	3.76	2.72	3.77	3.92	3.36	3.71	3.85	3.6
Black Pepper	0.05	0.09	0.06	0.09	0.1	0.07	0.08	0.08	0.1	0.13	0.09
Methi		0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.02	0.02
Tamarind		0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Areca Nut		0.4	0.42	0.44	0.45	0.44	0.55	0.69	0.8	0.91	0.97

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Garlic	0	0	0	0	0	0	0	0	0	0	0
Dry Ginger		0	0	0	0	0	0	0	0	0	0
Turmeric		0	0	0	0	0	0	0	0	0	0
Cloves		0	0	0	0	0	0	0	0	0	0
Other Condiments And Spices		0	0	0	0	0	0	0	0	0	0
Kapas	0.25	18.42	19.48	18.95	16	17.52	17.9	14.84	19.28	18.66	16.62
Sannhemp		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mesta	0	0	0	0	0	0	0	0	0	0	0
Jute		0	0	0	0	0	0	0	0	0	0
Cocoa	0.95	0.13	0.14	0.24	0.39	0.31	0.36	0.36	0.22	0.23	0.24
Coffee	0.25	1.76	1.63	1.76	1.79	1.6	1.61	1.6	1.5	1.7	1.74
Opium	0.05	0	0	0	0	0	0	0	0	0	0
Tea	0	0	0	0	0	0	0	0	0	0	0
Tobacco Leaf		0	0	0	0	0	0	0	0	0	0
Tobacco Stem		0	0	0	0	0	0	0	0	0	0

Crops	Dependence Rate	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Mulberry	**0.25**	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Guar Seed	**0.05**	1.27	1.87	1.7	1.43	0.95	0.84	0.7	0.81	0.71	0.63
Rubber	**0**	0	0	0	0	0	0	0	0	0	0
Mushroom		0	0	0	0	0	0	0	0	0	0
Paddy	**0**	0	0	0	0	0	0	0	0	0	0
Wheat		0	0	0	0	0	0	0	0	0	0
Bajra		0	0	0	0	0	0	0	0	0	0
Barley		0	0	0	0	0	0	0	0	0	0
Maize		0	0	0	0	0	0	0	0	0	0
Ragi		0	0	0	0	0	0	0	0	0	0
Small Millets		0	0	0	0	0	0	0	0	0	0
Sugarcane	**0**	0	0	0	0	0	0	0	0	0	0
Other Sugars		0	0	0	0	0	0	0	0	0	0
Total		**110.73**	**113.75**	**108.75**	**109.22**	**117.43**	**121.44**	**119.59**	**131.67**	**134.48**	**136.11**