

ISBN-978-93-94174-53-5

Ecological Study on Vegetation Structure in Hadagarh Forests of Keonjhar District, Odisha, India

- Dr. Ashis Kumar Dash
- Dr. V. P. Upadhyay
- Prof. H. K. Patra



First Edition

Excellent Publishers

Ecological Study on Vegetation Structure in Hadagarh Forests of Keonjhar District, Odisha, India

Dr. Ashis Kumar Dash,
KBLPA, Ministry of Jal Shakti,
Government of India.

Dr. V.P. Upadhyay
Former Adviser, Government of India,
Ministry of Environment, Forest & Climate, India

Prof. Hemanta Kumar Patra
Former HOD,
Department of Botany, Utkal University, India

Ecological Study on Vegetation Structure in Hadagarh Forests of Keonjhar District Odisha, India

**Author(s) : Dr. Ashis Kumar Dash
Dr. V.P. Upadhyay
Prof. Hemanta Kumar Patra**

ISBN : 978-93-94174-53-5

Page(s) : 137

Published Year : 2024

Published by : Excellent Publishers
No. 38/48, Second street, Ellappa Nagar
Kanchipuram – 631501, Tamilnadu, India.
Cell +91-9842641794
excellentpublishers2013@gmail.com
www.excellentpublishers.com



Disclaimer :

The author is solely responsible for the contents of the book in this volume in any manner, Errors, if any are purely unintentional and readers are requested to communicate such errors to the authors to discrepancies in futures.

Note: No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Copyright © 2024 Excellent Publishers, All Rights Reserved

PREFACE

Phytosociological study occupies the central part of any ecological research and provide valuable insights into plant communities and ecosystems. Therefore, vegetation study should be assigned an important role in informed decision-making, conservation efforts, and sustainable development policy initiatives. This book is a presentation of research output from the PhD thesis entitled 'Ecological Study on Vegetation Structure in Hadagarh Forests of Keonjhar District Odisha, India'.

In the quest to understand the intricate tapestry of nature and the delicate balance that sustains itself, extensive work was carried out in the forests of Hadagarh forests, a sanctuary with unique biodiversity located in Odisha, a state located in eastern part of India. It is within this spirit of ecological inquiry that the following pages in the book unfold, portraying an in-depth investigation into the forest vegetation of the area. The forests and its three important vegetation layers i.e trees, shrubs and herbs have long captivated the imagination of researchers and conservationists alike. The urge to unravel the treasure of bio- diversity with each species being a thread in the rich fabric of this unique ecosystem and the intricate dynamics propelled us on this journey that encompassed not only the tangible aspects of flora but also the deeper ecological nuances that shape the sanctuary's identity.

At the core of our endeavour lay a series of objectives meticulously crafted to describe every facet of the forest vegetation. First and foremost was to conduct a comprehensive reconnaissance survey, a foundational step in our journey to unveil the sanctuary's ecological wealth. Through this survey, we selected representative sites that would serve as windows into the diverse habitats and communities. Once these sites were identified, our focus shifted to documentation; a meticulous cataloguing of the species that forms the sanctuary's landscape. In addition to enumeration with the help of phytosociological tools, we delved deeper, seeking to unravel the intricate web of relationships that signifies the sanctuary's vegetation e.g frequency, density, abundance, IVI, basal area, equitability, concentration of dominance, species richness, maturity index, species diversity, β -diversity, Presence x Frequency (PXF) value, population structure, and regeneration potential, each contributed to ecological understanding we sought to focus.

We also discerned patterns of distribution that hint at the underlying processes shaping the sanctuary's vegetation communities. Through rigorous

analysis and interpretation, we endeavoured to unveil the species distribution and abundance, offering insights into the sanctuary's ecological dynamics. It is not enough to merely understand nature; we must also strive to conserve and protect it for future generations. Underlining this philosophy, we also ventured into the realm of ecological management, offering recommendations based on our findings.

We find that the objectives of declaring the area as a protected area have not been truly fulfilled with the current management practices. Hence, the vegetation of the sanctuary requires immediate attention from the perspective of habitat conservation and needs expeditious management interventions for regeneration of species. Also, the urgent need to curb the present anthropogenic interferences emanating both from within and outside the sanctuary has been highlighted in this book. The phytosociological analysis of the sanctuary exhibited fair regeneration potential of the flora. Trees with low IVIs and seedlings and saplings require management intervention for their uninterrupted growth. Strict enforcement and monitoring coupled with a comprehensive understanding of the present state of ecological health will help in addressing forest management problems of this habitat; a fact that forms the core of our recommendations.

Seedlings recruitment dynamics, especially in the periphery areas, needs more attention with a massive awareness drive partnering with the community living in and around the sanctuary. This will lead to better regeneration leading to well stocked forests in the area. Protection will help the forest-dwelling population meet their livelihood resources in a sustainable manner. In this context, a participatory approach will go a long way in preserving the existing vegetation and help the seedlings grow faster. Therefore, modification of the management methodology by devising a Long-Term Research Ecological Network(LTER) is recommended. The improvement in the functioning of the ecosystem and habitat conservation has been emphasized along with incorporation of a more scientific management system based on comprehensive research findings in the Working Plan for the management of the Wildlife Sanctuary.

We hope, this book will serve as a beacon of knowledge and inspiration, guiding the present and future generations in their quest to understand the mysteries of our precious ecosystems and act as a tool for devising conservation strategies for researchers, policy makers and regulators.

Authors

About Author(s)

Dr. Ashis Kumar Dash



Dr. Ashis Kumar Dash specializes in Environment Impact Assessment and Management of River Valley Projects in India. He has Masters & MPhil in Environment Science from Sambalpur University and Ph.D in Environment Science from Utkal University, India.

During a span of more than two decades he has been involved with Environment Impact Assessment and Management of River Valley Projects in states like Arunachal Pradesh, Assam, Uttarakhand, Himachal Pradesh, Madhya Pradesh and Uttar Pradesh. He has more than 23 years of experience in various thrust areas such as; Preparation of Prefeasibility Reports (PFR), Detailed Project Reports (DPR), Environment Impact Assessment and Environment Management, Rehabilitation & Resettlement Plans including first hand implementation of Environment & Forest Acts (Environment, Forest and Wildlife clearances) and management plans like Catchment Area Treatment, Compensatory Afforestation, restoration of dumping areas, conservation of Biodiversity in hydro and irrigation projects located in varied geographical locations spreading across multicultural socio-economic environment in India. During this period he had worked in NHPC Ltd (A Govt. of India Enterprise under Ministry of Power) and currently with KBLPA, Ministry of Jal Shakti, Government of India.

Dr. V.P. Upadhyay



Dr. V.P. Upadhyay did Ph.D. in Botany (Forest Ecology) from Kumaun University Nainital, India. He carried out research from 1981-1989 on Structure and Functioning of Himalayan Forest Ecosystems especially on Decomposition and Nutrient Release and Eco-Restoration of Ecosystems. In the Ministry of Environment, Forest & Climate Change (MoEFCC), he served in the Eastern, North Eastern and Central Regional Offices and also in HQ New Delhi. He retired as Adviser from Government of India, MoEFCC in July, 2018. He is a Fellow of International Society for Tropical Ecology (FTE), Eastern Himalayan Society for Spermatophyte Taxonomy (FEHSST) and National Institute of Ecology (FNIE) and has received “Environmental Conservation Awareness Award” from Odisha Environmental Society from His Excellency Hon’ble Governor of Odisha. IME Journal and Society for Geoscientists & Allied Technologists (SGAT) awarded him with Life Time Achievement Award. SGAT Odisha also felicitated him for work on Environmental Conservation and Management.

Prof.(Dr.)Hemanta Kumar Patra



Prof.(Dr.)Hemanta Kumar Patra was born on 9th October, 1952 of Kendrapara District, Odisha, India. He qualified B.Sc.(Hons), M.Sc. and Ph.D. Degree in Botany under Utkal University. He started his research career with the award of UGC Junior Research Fellowship. Subsequently he has been awarded CSIR Senior Research Fellowship/Post-Doctoral Fellowship, UGC Visiting Associate ship, USSR Govt's Post-Doctoral Fellowship (At Moscow State University), German Govt's DAAD Fellowship (At University of Hohenheim) and UGC award for Visiting Professor to University of Hohenheim (Germany). Consequently, Dr. Patra was honoured with the award of CSIR-Emeritus Scientist Fellowship (2012-2017) and UGC Emeritus Fellowship (2017-1019) for advance research in Environmental Biotechnology and worked for the period of 7 years in the Department of Botany, Utkal University. Subsequently he joined as professor Emeritus in Centurion University, Bhubaneswar with effect from 2021-2023. Now he is also working as a guest faculty in the Dept. of Botany, Utkal University with effect from 2012 and involved in Post-Graduate teaching in Environmental Science & Microbiology. Earlier, he was HOD, Department of Botany from 2000 to 2002.

Prof. Patra has been privileged with several awards naming a few 'Eminent & Best Scientist of the year Award by National Environmental Science Academy (2004,2005) and 'International Benevolent Research Fellowship (Environmental Science)' in 2005. Being the fellows of various renowned science societies like 'Fellow of Indian Society of Agricultural Biochemists:FISAB-2001', 'Fellow of National Environmental Science Academy:FeNESA-2006' and 'Fellow of National Environmentalist Association:FeNEA-2009', he earned pride to the country. Prof.Patra has also been awarded Professor Harihar Pattanaik Memorial Award in the field of Environmental Biology and College of Basic Science & Humanities Award for his significant contribution to Botany by Orissa Botanical Society. He was elected as president, Orissa Botanical Society for the year 2015. The Department of Botany, Utkal University came to lime light for its advance research by the recognition UGC & DST funded under DRS-SAP and FIST programme during the year 2000 with his leadership.

His expertise research outputs in the field of Stress Biology and Environmental Biotechnology have been recognised through his publications and wide-ranging citations. He has successfully executed research projects funded by UGC, CSIR, NORAD, IBM (Coal & Mines, Govt. of India), MoEF (Govt. of India) and MCCL Ltd. Prof Patra has published 217 research papers in peer-reviewed international/national journals, book chapters including the proceedings of the national and international seminars. He has published 11 books/ proceedings and 27 scientific articles in Science Reporter and others. To date, Dr. Patra has guided one D.Sc. and 25 Ph.D. students of Utkal University. Dr Patra has organised 11 national/state level seminars/workshops and chaired/delivered lectures in International /National seminars. He has successfully managed editorial assignment as Chief-Editor, Managing Editor and reviewers of various journals at the state, national and international level.

Table of Contents

Ch. No.	Titles		Page No.
	Contents		x
	List of Tables		xvi
	List of Figures		xvii
1	INTRODUCTION		1-14
	1.1	Biodiversity and Forests	2
	1.2	Forest Management	4
	1.3	Phytosociology	5
	1.4	Hadagarh Wildlife Sanctuary	6
	1.4.1	Forest vegetation of the Sanctuary	6
	1.4.2	Biotic interference on forest vegetation	9
	1.4.2.1	Biotic Interferences: Anthropogenic causes	10
	1.4.2.2	Natural Interferences	12
	1.4.3	Tribes and their dependency on the forest wealth of Hadagarh Wildlife Sanctuary	12
	1.4.4	Bio-geographical classification	13
	1.4.5	Geographical area	13
	1.5	Present Study	13
2	ECOLOGICAL STUDY ON VEGETATION STRUCTURE		15-20
	2.1	Phytosociology	15
	2.2	Species Diversity	16
	2.3	Environmental Impacts and Diversity	17
	2.4	Disturbance- Diversity Relation	18
	2.5	Ethno- Botanical Significance of Plant Species	19
3	THE STUDY SITES		21-36
	3.1	Location	21
	3.2	The Study Site	21
	3.3	Terrain	21
	3.4	Climate	22
	3.5	Natural Disasters in the District	25

	3.6	Vegetation			25
	3.7	Geology and Soil Characteristics			26
	3.8	The Selection of Study Sites			27
	3.9	Photographs of Study Sites			28
	3.10	Photographs of Villages Located in Hadagarh Wildlife Sanctuary			33
4	METHODOLOGY FOR ECOLOGICAL STUDY				37-41
	4.1	Analysis			37
		4.1.1	Methods for Quadrat size and number		37
			4.1.1.1	The Tree Vegetation Layer	37
			4.1.1.2	The Shrubs & Saplings and Herbs & Seedlings Vegetation Layer	37
		4.1.2	Vegetation Analysis		37
			4.1.2.1	Primary Analysis of Parameters	38
				4.1.2.1.1 Frequency	38
				4.1.2.1.2 Relative Frequency	38
				4.1.2.1.3 Density	38
				4.1.2.1.4 Relative Density (RD)	38
				4.1.2.1.5 Abundance (A)	38
				4.1.2.1.6 Girth Class	39
				4.1.2.1.7 Basal Area (BA) /Dominance	39
				4.1.2.1.8 Important Value Index (IVI)	39
			4.1.2.2	Secondary analysis of Parameters	39
				4.1.2.2.1 Distribution pattern	39
				4.1.2.2.2 Maturity Index (MI)	39
				4.1.2.2.3 Similarity Index / Community Coefficient	39
				4.1.2.2.4 Species Diversity	40
				4.1.2.2.5 Concentration of Dominance	40
				4.1.2.2.6 Species Evenness Index	40
				4.1.2.2.7 Species Richness Index	40
				4.1.2.2.8 Beta Diversity	40
				4.1.2.2.9 PXF Index	41
			4.1.2.3	Population Structure	41
5	RESEARCH ANALYSIS OF ECOLOGICAL STUDY ON VEGETATION STRUCTURE				42-99

5.1	Phytosociological Analysis			42
	5.1.1	Upper Strata/Storey: The Tree Vegetaion Layer		42
		5.1.1.1	The Density and The Basal Area	42
		5.1.1.2	Frequency and distribution pattern	46
	5.1.2	The Shrubs And Saplings Vegetation Layer		50
		5.1.2.1	Density and Basal Area	50
		5.1.2.2	Frequency and Distribution Pattern	51
	5.1.3	The Herbs and Seedlings Vegetation Layer		56
		5.1.3.1	Density	56
		5.1.3.2	Frequency and distribution pattern	57
5.2	Floristic Composition			61
	5.2.1	Upper Strata/Storey: The Tree Vegetation Layer		62
	5.2.2	Middle Strata/Storey: The Shrubs and Saplings Vegetation Layer		63
	5.2.3	Under Strata/Storey: The Herbs and Seedlings Vegetation Layer		64
5.3	Important Value Index (IVI) and Dominance			65
	5.3.1	IVI of the Upper Strata/Storey: The Tree Vegetation Layer		65
	5.3.2	IVI of the Middle Strata/Storey: The Shrubs and Saplings Vegetation Layer		67
	5.3.3	IVI of under Strata/Storey: The Herbs and Seedlings Vegetation Layer		67
5.4	Similarity Index			67
	5.4.1	The Upper Strata/Storey: The Tree Vegetation Layer		67
	5.4.2	Middle Strata/Storey: The Shrubs and Saplings Vegetation Layer		68
	5.4.3	Under Strata/Storey: The Herbs and Seedlings Vegetation Layer		68
	5.4.4	Statistical Analysis of phytosociological parameters: vegetation layers and zones		69
5.5	Diversity and Associated Indices			71
	5.5.1	The Upper Strata/Storey: The Tree Vegetation Layer		71
		5.5.1.1	The Species richness and evenness Indices	71
		5.5.1.2	Species Diversity	72
		5.5.1.3	Concentration of Dominance	74
		5.5.1.4	Maturity Index	74

	5.5.2	The Middle Strata/Storey: The Shrubs and Saplings Vegetation Layer	75
	5.5.2.1	The Species diversity and Cd	75
	5.5.2.2	Species richness and evenness	75
	5.5.3	The Under Strata/Storey: The Herbs and Seedlings Vegetation Layer	76
	5.5.3.1	Species richness and evenness values	76
	5.5.3.2	Species diversity and Cd	77
	5.5.3.3	β -Diversity	78
	5.5.3.4	Statistical Analysis of Biodiversity Indices: vegetation layers and zones	79
	5.5.3.5	Correlation Coefficient of Phytosociological Parameters and Biodiversity Indices	79
	5.6	PxF Index	83
	5.6.1	The Upper Strata/Storey: The Tree Vegetation Layer	83
	5.6.2	The Middle Strata/Storey: The Shrubs and Saplings Vegetation Layer	84
	5.7	Dominance – Diversity (DD) Curves	84
	5.8	Population Structure	91
	5.9	Use of Non-Timber Forest Produce by Tribals in the Sanctuary	96
6	SUMMARY AND SCOPE		100-104
	REFERENCES		105-122

LIST OF TABLES

Sl. No.	Table	Page No.
1.1	State of Forest :Keonjhar District (Odisha)	4
1.2	Common Plant Species of Trees, Shrubs and Others	7
1.3	Species declared as reserved species	11
1.4	Geographical Area of the Sanctuary	13
3.1	Monthly Rainfall data (Average in mm) Keonjhar District, Odisha, India	23
3.2	History of disasters in the area	24
3.3	Trend of Disasters in Keonjhar District	25
3.4	Biogeographic Zones and Location of Sanctuaries in Odisha	26
3.5	Characteristic features of study sites	27
5.1	Density, Basal Area of Tree species in Hadagarh Wildlife Sanctuary	43
5.2	Density and Basal area of Trees of Tropical Forests	43
5.3	Distribution of Tree Species with respect to Frequency Classes at study sites in Hadagarh Wildlife Sanctuary	47
5.4	Distribution pattern of Tree layer at sites of Hadagarh Wildlife Sanctuary	49
5.5	Analysis of variance between study sites and Phytosociological parameters (Density, Abundance, Frequency & Basal Area) of Trees of Hadagarh Wildlife Sanctuary	50
5.6	Density, Basal Area of Shrubs and Sapling species in Hadagarh Wildlife Sanctuary	51
5.7	Distribution of Shrubs and Sapling Species with respect to Frequency Classes at study sites	52
5.8	Distribution percentages of Shrubs and Saplings in Hadagarh Wildlife Sanctuary	55
5.9	Analysis of variance between sites and Phytosociological parameters (Density, Abundance & Frequency) of Shrubs and saplings of Hadagarh Wildlife Sanctuary	55
5.10	Density of Herbs and Seedlings species in Hadagarh Wildlife Sanctuary	56
5.11	Distribution of Herbs and Seedlings Species with respect to Frequency Classes at study sites	57
5.12	Distribution percentages of Herbs and seedlings in Hadagarh Wildlife Sanctuary	60
5.13	Analysis of variance between sites and Phytosociological parameters (Density, Abundance & Frequency) of Herbs and Seedlings	61
5.14	Floristic Diversity (Species, families and genera) of Trees species (>31 cm cbh)	62

	in Hadagarh Sanctuary	
5.15	Correlation Coefficient of tree species among three different zones of Hadagarh Wildlife Sanctuary	63
5.16	Correlation Coefficient of Shrubs and Saplings species among three different zones of Hadagarh Wildlife Sanctuary	63
5.17	Floristic Diversity (Species, families and genera) of Shrubs and Sapling species (10-31 cm cbh) in Hadagarh Sanctuary	64
5.18	Floristic Diversity (Species, families and genera) of Herbs and Seedlings (<10 cm cbh) species in Hadagarh Wildlife Sanctuary	64
5.19	Correlation Coefficient of Herbs and Seedlings species among three different zones of Hadagarh Wildlife Sanctuary	65
5.20	The Similarity Index among study sites	68
5.21	Similarity Index of Shrubs and Saplings among sites	69
5.22	Similarity Index of Herbs and Seedlings	69
5.23	Analysis of Variance of Density among different vegetation layers of Hadagarh Wildlife Sanctuary	70
5.24	Analysis of Variance for abundance among different vegetation layers Hadagarh Wildlife Sanctuary	70
5.25	Analysis of Variance for Basal area among different vegetation layers of Hadagarh Wildlife Sanctuary	70
5.26	Analysis of Variance for frequency among different vegetation layers of Hadagarh Wildlife Sanctuary	71
5.27	Species Richness, Evenness, Species Diversity, Conc. of Dominance and Maturity Index of Tree Vegetation layer of Hadagarh Wildlife Sanctuary	71
5.28	Diversity Index of different Tropical forest communities in India & other countries	72
5.29	Anova: Two-Factor without replication (Diversity indices) Tree Layer	75
5.30	Species Richness, Species Evenness, Diversity, Conc. of Dominance and Maturity Index of Shrubs and Saplings Vegetation layer of Hadagarh Wildlife Sanctuary	75
5.31	Anova: Two-Factor without Replication (Diversity indices) Shrubs and saplings	76
5.32	Species Richness, Species Evenness, Diversity, Conc. of Dominance and Maturity Index of Herbs and Seedlings Vegetation layer of Hadagarh Wildlife Sanctuary	76
5.33	Anova: Two-Factor without replication (Diversity indices) Herbs and seedlings	77
5.34	β -Diversity of different vegetation layers in Hadagarh Wildlife Sanctuary	78
5.35	F-analysis of species richness of different vegetation layers of Hadagarh Wildlife Sanctuary	79
5.36	F-analysis of evenness index of different vegetation layers of Hadagarh Wildlife	80

	Sanctuary	
5.37	F-analysis of Shannon Weiner diversity index of different vegetation layers of Hadagarh Wildlife Sanctuary	80
5.38	F-analysis of Simpson's index of dominance of different vegetation layers of Hadagarh Wildlife Sanctuary	80
5.39	F-analysis of maturity index of different vegetation layers of Hadagarh Wildlife Sanctuary	80
5.40	Correlation coefficient between Tree vegetation layers of Hadagarh Wildlife Sanctuary	81
5.41	Correlation coefficient between Shrubs and Saplings layers of Hadagarh Wildlife Sanctuary	81
5.42	Correlation Matrix of Herbs and Seedlings layers of Hadagarh Wildlife Sanctuary	82
5.43	PxF Index of Dominant Trees of Hadagarh Wildlife sanctuary	83
5.44	PxF Index of Dominant shrubs and saplings of Hadagarh Wildlife sanctuary	83
5.45	Population structure of dominant species across Hadagarh Wildlife sanctuary	92
5.46	Population Structure of dominant species at different study sites	93
5.47	Non-Timber Forest Produces (NTFPs) used by tribes in Hadagarh Wildlife Sanctuary	97

LIST OF FIGURES

Sl. No.	Figure	Page No.
3.1	Location and Approach Map of Hadagarh Wildlife Sanctuary	22
3.2	Odisha Meteorological Subdivision Map	23
3.3	Average annual rainfall pattern in Keonjhar District, Odisha, India	24
3.4	View of Study Site-I (Near Gadachandi area)	28
3.5	View of Study Site-I (Near Gadachandi area)	28
3.6	View of Study Site-II (Dam Site-Zero point of Hadagarh Forests)	29
3.7	View of the Hadagarh Reservoir near Study Site-II	29
3.8	View of Study Site-III (Chakratirtha area)	30
3.9	View of Study Site-IV (Kathakata area)	31
3.10	View of Study Site-IV (Kathakata Area)	31
3.11	View of Study Site-V (Pitanau area)	32
3.12	View of Study Site-V (Pitanau area)	32
3.13	View of Study Site-VI (Mallipasi area)	32
3.14	View of Study Site-VI (Mallipasi Area)	33
3.15	View of Village Phulajhara Located inside the Sanctuary	33
3.16	View of a typical Village house located inside the Sanctuary	34
3.17	View of use of NTFPs by a villager residing inside the Sanctuary	34
3.18	Glimpse of village Pitanau located inside the Core area of Sanctuary	35
3.19	Glimpse of a village life in Core area of the Sanctuary	35
3.20	View of road connecting Kathakata and Chakratirtha areas of the Sanctuary	36
5.1	Frequency Class distribution of Tree Species at study site-1	47
5.2	Frequency Class distribution of Tree Species at study site-2	47
5.3	Frequency Class distribution of Tree Species at study site-3	48
5.4	Frequency Class distribution of Tree Species at study site-4	48
5.5	Frequency Class distribution of Tree Species at study site-5	48
5.6	Frequency Class distribution of Tree Species at study site-6	49
5.7	Frequency Class distribution of Shrubs and Saplings at study site-1	52
5.8	Frequency Class distribution of Shrubs and Saplings at study site-2	52
5.9	Frequency Class distribution of Shrubs and Saplings at study site-3	53

5.10	Frequency Class distribution of Shrubs and Saplings at study site-4	53
5.11	Frequency Class distribution of Shrubs and Saplings at study site-5	54
5.12	Frequency Class distribution of Shrubs and Saplings at study site-6	54
5.13	Frequency Class distribution of Herbs and Seedlings at study site-1	58
5.14	Frequency Class distribution of Herbs and Seedlings at study site-2	58
5.15	Frequency Class distribution of Herbs and Seedlings at study site-3	58
5.16	Frequency Class distribution of Herbs and Seedlings at study site-4	59
5.17	Frequency Class distribution of Herbs and Seedlings at study site-5	59
5.18	Frequency Class distribution of Herbs and Seedlings at study site-6	59
5.19	Dominance-Diversity Curve of Tree vegetation layer of study site-1	84
5.20	Dominance-Diversity Curve of Tree vegetation layer of study site-2	85
5.21	Dominance-Diversity Curve of Tree vegetation layer of study site-3	85
5.22	Dominance-Diversity Curve of Tree vegetation layer of study site-4	85
5.23	Dominance-Diversity Curve of Tree vegetation layer of study site-5	86
5.24	Dominance-Diversity Curve of Tree vegetation layer of study site-6	86
5.25	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-1	87
5.26	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-2	87
5.27	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-3	87
5.28	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-4	88
5.29	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-5	88
5.30	Dominance-Diversity Curve of Shrubs and Saplings layer of study site-6	88
5.31	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-1	89
5.32	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-2	89
5.33	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-3	89
5.34	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-4	90
5.35	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-5	90
5.36	Dominance-Diversity Curve of Herbs and Seedlings layer of study site-6	90
5.37	Population structure of Hadagarh Wildlife Sanctuary	91
5.38	Population structure of dominant species of Hadagarh Wildlife sanctuary	93
5.39	Population Structure of Site-1 (Gadachandi Area)	94
5.40	Population Structure of Site-2 (Zero point)	94
5.41	Population Structure of Site-3 (Chakratirtha)	95

5.42	Population Structure of Site-4 (Kathakata)	95
5.43	Population Structure of Site-5 (Pitanau)	95
5.44	Population Structure of Site-6 (Mallipasi)	96
5.45	Percentage use of NTFP by tribes living in Hadagarh Wildlife Sanctuary	96

ISBN-978-93-94174-53-5

First Edition



Excellent Publishers

Kancheepuram, India

www.excellentpublishers.com

ISBN 978-93-94174-53-5



9 789394 174535