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Plant-Bacteria Associations for Remediation of Crude Oil Pollutants with a Special Emphasis on Application Potential of Plant Growth Promoting Rhizobacteria (PGPRs)

Paramita Chakravarty
Hemen Deka

Abstract

Crude oil pollution is a major and severe problem in several countries round the globe. Crude oil contains several pollutants such as hydrocarbons (HCs) including polycyclic aromatic hydrocarbons (PAHs), heavy metals (HMs) and others. Some of the HCs are comparatively more stable in the environment and natural biodegradation of these compounds is very slow and even difficult. The remediation techniques involving both plant and bacteria more particularly plant growth-promoting rhizobacteria (PGPRs) is an efficient, cheap and economically viable options for the removal of HCs from the contaminated habitats. The combined use of plants and the associated microbes/bacteria for remediation of crude oil pollutants has been considered as the new and most relevant concept in the field of bioremediation. Plants and their associated PGPRs interact with each other where plant supplies carbon as special food source to the bacteria that can stimulate the bacteria to degrade hydrocarbon pollutants in the growth matrix. In return, PGPRs synthesize chemicals/enzymes to stimulate plant growth and promote nutrients uptake and thereby enhancing the capacity of plants against contaminated-induced stress, lowering of both phytotoxicity and evapotranspiration of volatile hydrocarbons. This chapter is attempted to highlight about the works carried out on effective and potential use of plant-bacteria associations for remediation of crude oil pollutants from contaminated habitats besides addressing the limitations and research gaps.

Chapter 11

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Crude Oil Associated Abiotic Stresses on Herbaceous Plants

Tridip Boruah
Hemen Deka

Abstract

Crude oil is an intricate composition of both aliphatic and aromatic hydrocarbons, asphaltenes, resin and many organic as well as organometallic compounds. Crude oil contaminations negatively affect the biological activity and productivity of ecosystem by changing the dynamics of soil parameters such as pH, electrical conductivity, moisture content, aeration, water holding capacity and nutrients compositions. Being one of the principal producers of the ecosystem the herbaceous plant communities plays a vital role in the establishment of homeostasis of the ecosystem. The growth, structure and phenology of herbaceous plant communities are severely influenced by ecological, anthropogenic, climatic and biogeochemical processes on the earth. The herbaceous plant species must have some adaptive advantages and possess certain mechanisms of stress tolerance which make them suitable for fast acclimatization in crude oil polluted environment. The entry of pollutants cause the injury to biological membrane by accumulating reactive oxygen species, inhibits photosynthesis as well as transpiration and finally lead to the death of plants. Reduction of growth, senescence, abnormal root and shoot development, light receptor destruction, reduction of photosynthetic efficiency, rate of absorption, stomatal movement, flowering response, water conducting system are significantly affected by crude oil associated abiotic stresses. This chapter is attempted to focus the impact of crude oil contaminations on herbaceous plant communities, their potential defense mechanism against hydrocarbons associated stresses besides highlighting the research gap in the north east India including Assam.

Chapter 15

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Nanomaterials for Removal of Polycyclic Aromatic Compounds (PACs) and Heavy Metals (HMs)

Shaleh Akram
Hemen Deka

Abstract

The challenging task of this century is to clean up the contaminants by eco-friendly, sustainable and economically viable technologies. Polycyclic aromatic hydrocarbons (PAHs) and heavy metals (HMs) are the major contaminants of environment that shows detrimental affects on living organisms including human beings. Nanomaterials are more reactive and have large surface area than its bulk phase, so it has a wide range of applications including bioremediation. For the unique property of nanomaterials, it can also be applied to clean up PAHs and HMs contaminated sites. For remoal of contaminants/pollutants nanomaterials can be applied in two ways. The first one is direct application for the removal of contaminants and the second one is the removal of contaminants through adsorption or chemical modification. Nanomaterials enhance remediation of contaminants by microorganisms either by increasing the microbial growth or stabilizing the remediating agents or through induced production of remediating microbial enzymes. Besides, nanoparticles also reduce the hydrophobicity and create a conductive environment in the contaminated sites and also enhance the microbial degradation process. In this chapter application potential of various nanomaterials for remediation of PAHs and HMs has been discussed besides the brief highlights about their limitations.

Chapter 7

Heavy Metals (HMs) Dynamics During Vermicomposting of Organic Wastes: Current Understanding and Future Prospects

Tridip Boruah and Hemen Deka*

Department of Botany, Ecology and Environmental Remediation Laboratory, Gauhati University, Guwahati-14, Assam, India

Keywords	Abstract
Earthworms; Vermiremediation; Ecotoxicity; Bioaccumulation	*Vermicomposting is a mesophilic process that involves the combined interaction of earthworms and microbes resulting in efficient stabilization of large quantities of organic waste. The end product of the vermicomposting process is a well-known commodity for not only increasing the soil fertility but also amplifying the biomass of beneficial microbial populations while reducing the unwanted harmful microbes. Heavy metal toxicity is one of the major growing concerns in the vermicomposting systems because not only it has an adverse effect on plants but it also destabilizes the microbial community responsible for plant growth and development. Therefore it is necessary to understand the distribution, mobility, transport, bioavailability, uptake and the ultimate fate of heavy metals in the vermicomposting system to gain further knowledge about the ecotoxicity of vermicompost. This chapter will focus on the heavy metals (HMs) toxicity of vermicompost to understand the mechanism of heavy metal dynamics in the vermicomposting system following the degradation pathways of HMs in the vermicomposting systems; along with that the role of microbes and earthworms in the detoxification of heavy metals.*

*Corresponding author; e-mail: hemendeka@gauhati.ac.in

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Bio-Based Polymers and Composites
Properties, Durability, and Applications

Editors: Amadou Belal Gueye
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This volume, **Bio-Based Polymers and Composites: Properties, Durability, and Applications,** takes its inspiration from Nature as the source of innumerable and priceless resources. When applying human ingenuity and experience to natural resources and processes, scientists and researchers can maximize the potential of nature for human benefit. In that vein, this new volume explores the latest breakthroughs in natural biopolymers, green composites, and green nanocomposites, a field that is rapidly expanding.

This book consolidates information on the synthesis and applications of biopolymers, green composites, and green nanocomposites for various applications with detailed characterization, mechanical approaches, and theoretical consideration. Recent development in advanced devices using nanostructured materials are covered. This book provides fundamentals and advanced concepts for developing nanostructured materials based on biopolymers and their composites.

The volume also looks at bio-based polymers and composites for environmental sustainability, such as in bioremediation and for wastewater treatment. It discusses natural polymers from waste products. It considers the use of bio-based polymers and composites in fertilization in horticulture as well as in industry and construction, for recycling of concrete, for gas sensing applications for safety, for fiber-reinforced epoxy composites, etc. In medicine, a study shows the use of biopolymers and green composites for measuring the blood glucose concentration of a patient.

Over the past 20 years, the size and sophistication of natural polymers and biomaterials have significantly increased due to advances in science, technology, and business. The circumstance has compelled academic and industrial researchers to do substantial research in these fields. Academicians (undergraduate to doctoral students and researchers) and professionals will be interested in this volume.

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3. Lignin- and Chitosan-Based Biosorbents for Wastewater Treatment
Jyothy G. Vijayan

C H A P T E R

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c0011
[AU3]

Instrumental characterization of matured vermicompost produced from organic waste

[AU4]

W James Singha and Hemen Deka

Ecology and Environmental Remediation Laboratory, Department of Botany, Gauhati University, Guwahati, Assam, India

s0010

1. Introduction

p0010   Fertilization is one of the most effective ways to increase the efficiency of obtaining better return products in the agricultural sector (Klimczyk et al., 2021). However, the rampant utilization of chemical fertilizers to meet food demands in recent decades has raised serious concern due to its association with pollution in water, air, and soil, increased emission of greenhouse gases, and reduction of soil fertility in the distant future (Nadarajan and Sukumaran, 2021; Kumar et al., 2019; Pahalvi et al., 2021; Srivastav, 2020). With the advent of science and an increase in understanding of the environment, there is a rising demand for adopting organic fertilizer as an alternative to replace or minimize the usage of chemical fertilizers (Nosheen et al., 2021). Organic fertilizers are derived from the residues of plants, vegetables, industrial waste, animal matter, and excreta (Diacono et al., 2019). They improve soil texture, nutrient profile, water-holding capacity, aeration, and beneficial microbial population, resulting in a higher output of agricultural crops (Lim and Wu, 2015). Besides, organic fertilizers are superior in the context of environmental management, quality of the product, and recycling of bio-waste (Verma et al., 2020). The population explosion in recent decades has resulted in sizable growth of bio-waste originating from agriculture, households, and

[AU5]   industries (Bhat et al., 2018a,b; Mirabella et al., 2014). Without adequate treatment, the disposal of these wastes might have harmful repercussions on human health and the sur-

[AU6]   rounding environment (Bhat et al., 2017a,b). Therefore, the conversion of this waste to a useful resource through nature-friendly methods is a rising interest in the issue of waste management (Taiwo, 2011).

Phytotaxa

Syzygium namborense (Myrtaceae), a new species from Assam, India

DEBOLINA DEY

Department of Botany, Gauhati University, Jalukbari, Guwahati, Kamrup (Metro), Assam-781014, India

https://orcid.org/0000-0002-0048-8363

JATINDRA SARMA

State Medicinal Plant Board, Department of Environment and Forest, Lankeswar, Jalukbari, Guwahati, Kamrup (Metro), Assam-781014, India

https://orcid.org/0000-0003-4635-5766

NILAKSHEE DEVI

Department of Botany, Gauhati University, Jalukbari, Guwahati, Kamrup (Metro), Assam-781014, India

https://orcid.org/0000-0002-6007-4904

Abstract

Syzygium namborense is described and illustrated as a new species from the Nambor Reserve Forest, Assam, India. It resembles *Syzygium nervosum* in having glabrous, chartaceous and aromatic leaves, paniculate inflorescences with second order branching, calyptrate flowers, numerous stamens and equal number of petals in the calyptra but differs from it in having more compressed branchlets with shorter nodes and greater number of leaves, shorter acumen, strictly elliptic leaves with acuminate apex and cuneate base, greater number of lateral veins, intramarginal vein uniform along the blade, sessile yellowish white flowers with obconical hypanthium and a higher number of ovules per locule.

References

Ambarish, A. (2013) *Floristic Diversity of Arunachal Pradesh (Upper Subansiri District).* Bishen Singh Mahendra Pal Singh, Dehra Dun, pp. 192–195.

Balakrishnan, N.P. (1981) *Flora of Jowai* 1. Botanical Survey of India, Howrah, India, pp. 198–201.

Brambach, F., Byng, J.W. & Culmsee, H. (2017) Five new species of *Syzygium* (Myrtaceae) from Sulawesi, Indonesia. *PhytoKeys* 81: 47–78. https://doi.org/10.3897/phytokeys.81.13488

Brown, R. (1820) *In*: Roxburgh, W. (Ed.) *Plants of the coast of Coromandel; selected from drawings and descriptions presented to the hon. court of directors of the East India Company* 3. Bulmer & Co., London, 95 pp. https://doi.org/10.5962/bhl.title.467

Byng, J.W., Wilson, P.G. & Snow, N. (2015) Typifications and nomenclatural notes on Indian Myrtaceae *Phytotaxa* 217 (2): 101–116. https://doi.org/10.11646/phytotaxa.217.2.1

Candolle, A.P. de (1828) Myrtaceae. *In* Candolle, A.P. de (Ed.) *Prodromus Systematis Naturalis Regni Vegetabilis* 3. Treuttel et Wurts, Paris, pp. 207–296. https://doi.org/10.5962/bhl.title.286

Chauhan, A.S. (2000) *Myrtaceae*. *In:* Singh, N.P., Chauhan, A.S. & Monda, M.S. (Eds.) *Flora of Manipur* Vol.1. Botanical Survey of India, Calcutta, pp. 385–388.

Chithra, V. (1983) *Myrtaceae*. *In:* Nair, N.C. & Henry, A.N. (Eds.) *Flora of Tamil Nadu, India. Series 1: Analysis.* Vol.1. Botanical Survey of India, Coimbatore, pp. 150–158.

Deb, D.B. (1981) *The Flora of Tripura State.* Vol. 1. Today & Tomorrow's Printers and Publishers, India, pp. 366–373.

Duthie, J.F. (1879) Myrtaceae. *In:* Hooker, J.D. (Ed.) *Flora of British India* 2. L. Reeve & Co., London. pp. 462–506. https://doi.org/10.5962/bhl.title.678

Gaertner, J. (1788) *De Fructibus et Seminibus Plantarum Stvtgardiae* 1. Academiae Carolinae Stvtgardiae, 577 pp. https://doi.org/10.5962/bhl.title.53838

Hajra, P.K., Verma, D.M. & Giri, G.S. (1996) *Materials for the Flora of Arunachal Pradesh.* Vol.1: *Ranunculaceae to Dipsacaceae.* Botanical Survey of India, Kolkata, pp. 470–479.

Haridasan, K. & Rao, R.R. (1985) *Forest flora of Meghalaya.* Vol. 1. B.S.M.P.S., Dehra Dun, India, pp. 386–403.

Kanjilal, U.N., Kanjilal, P.C. & Das, A. (1938) Myrtaceae. *In*: Kanjilal, U.N., Kanjilal, P.C. & Das, A. (Eds.) *Flora of Assam* 2. Government of Assam, Shillong, India, pp. 257–287.

King, R.M. & Robinson, H. (1970) Studies in the Eupatorieae (Compositae) XXI. The genus *Chromolaena*. *Phytologia* 20 (3): 196–209. https://doi.org/10.5962/bhl.part.7118

Kulkarni, B.G. (2001) *Myrtaceae*. *In:* Singh, N.P., Lakshminarasimhan, P., Karthikeyan, S. & Prasanna, P.V. (Eds.) *Flora of Maharashtra State.* Vol.2. Botanical Survey of India, Howrah, India, pp. 7–16.

Lindley, J. (1844) *Clerodendron glandulosum*. *Edward's Botanical Register* 30: 1–19.

Linnaeus, C. (1753) *Species Plantarum* 1. L. Salvius, Stockholm, pp. 200–471.
https://doi.org/10.5962/bhl.title.669

Linnaeus, C. (1759) *Systema Naturae*, 10th ed., vol. 2, 1205 pp. https://doi.org/10.5962/bhl.title.542

Loureiro, J. (1790) *Flora Cochinchinensis* 1. Ulyssipone, Lisbon, 296 pp.
https://doi.org/10.5962/bhl.title.40199

Merrill, E.D. (1919) Additional notes on the Kwangtung Flora. *The Philippine Journal of Science* 15: 1–249.

Murugan, C. & Manickam, V.S. (2004) Two additions to Myrtaceae of India. *Journal of Economic and Taxonomic Botany* 28: 523–526.

Nayar, T.S., Beegam, A.R., Mohanan, N. & Rajkumar, G. (2006) *Flowering Plants of Kerala – A Handbook.* TBGRI, Thiruvananthapuram, Kerala, pp. 445–455.

Nayar, T.S., Beegam, A.R. & Sibi, M. (2014) *Flowering Plants of the Western Ghats*, *India*. Jawaharlal Nehru Tropical Botanical Garden and Research Institute, pp. 669–687 & 1252 pp.

Pal, G.D. (2013) *Flora of Lower Subansiri district, Arunachal Pradesh (India)* Vol.1. Botanical Survey of India, Kolkata, pp. 317–322.

Ramana, M.V., Chorghe, A. & Venu, P. (2014) Two new species of *Syzygium* (Myrtaceae) from Saddle Peak National Park, Andaman and Nicobar Islands, India. *Blumea* 59: 42–48.
https://doi.org/10.3767/000651914X683593

Ramasubbu, R., Surendran, A., Chelladurai, D., Nambi, S.K. & Gurusamy, M. (2018) A new species of *Syzygium* (Myrtaceae) from the South Western Ghats of Tamil Nadu, India. *Phytotaxa* 374 (3): 263–267. https://doi.org/10.11646/phytotaxa.374.3.8

 Ramasubbu, R., Surendran, A & Kasi, K.S. (2020) *Syzygium anamalaianum* (Myrtaceae), a new tree species from the Western Ghats of Tamil Nadu, India. *Phytotaxa* 450 (2): 237–242.
https://doi.org/10.11646/phytotaxa.450.2.9

Robi, A.J., Sujanapal, P. & Sasidharan, N. (2014) *Syzygium sahyadricum* (Myrtaceae), a new tree species from India, and notes on the distribution of *S. spathulatum* Thwaites. *Phytotaxa* 174 (5): 285–290. https://doi.org/10.11646/phytotaxa.174.5.5

Roxburgh, R. (1832) *Flora Indica*; or, *Descriptions of Indian Plants* 2. Serampore: printed for W. Thacker and Co. Calcutta and Parbury, Allen and Co. London, pp. 482–497.
https://doi.org/10.5962/bhl.title.590

Saldanha, C.J. (1996) *Flora of Karnataka.* Vol. 2. Oxford & IBH Publishing, New Delhi, India, pp. 23–32.

Sarma, J., Barbhuiya, H.A. & Dey, S. (2019) A new rheophytic species of *Syzygium* Gaertn. (Myrtaceae) from Assam, North East India. *Adansonia* 3: 53–58. https://doi.org/10.5252/adansonia2019v41a6

Shareef, S.M., Santhosh Kumar, E.S. & Shaju, T. (2012) A new species of *Syzygium* (Myrtaceae) from the southern Western Ghats of Kerala, India. *Phytotaxa* 71: 28–33. https://doi.org/10.11646/phytotaxa.71.1.5

Shareef, S.M., Santhosh Kumar, E.S. & Roy, P.E. (2013) A new species of *Syzygium* (Myrtaceae) from Kerala, India. *Phytotaxa* 129: 34–38. https://doi.org/10.11646/phytotaxa.129.1.2

Shareef, S.M. & Santhosh Kumar, E.S. (2020) Census of *Syzygium* Gaertn. (Myrtaceae) in India. *Abrahamia* 6 (2): 90–107.

Singh, K.P. (2002) Myrtaceae. *In:* Singh, N.P., Singh, K.P. & Singh, D.K. (Eds.) *Flora of Mizoram.* Vol.1. Botanical Survey of India, Calcutta, pp. 585–594.

Skeels, H.C. (1912) 31571 *Syzygium cumini*. *In*: Galloway, B.T. (Ed.) Seeds and plants imported during the period from July 1 to September 30, 1911: Inventory No. 28. *Bulletin, Bureau of Plant Industry, United States Department of Agriculture* 25: 1–248.

Soh, W.K. & Parnell, J. (2015) A revision of *Syzygium* Gaertn. (Myrtaceae) in Indochina (Cambodia, Laos and Vietnam). *Adansonia* 3: 179–275. https://doi.org/10.5252/a2015n2a1

Sreekala, A.K., Pillai, D.S., Akhil, R., Surendran, A & Ramasubbu, R. (2019) A new species of *Syzygium* (Myrtaceae) from the Agasthyamalai Biosphere Reserve, Kerala, India. *Phytotaxa* 403: 66–70. https://doi.org/10.11646/phytotaxa.403.1.6

Sujanapal, P., Robi, A.J., Udayan, P.S. & Dantus, K.J. (2013) *Syzygium sasidharanii* sp. nov. (Myrtaceae)- A new species with edible fruits from Agasthyamala Hills of Western Ghats. India. *International Journal of Advanced Research* 5: 44–48.

Turner, I.M. & Gandhi, K.N. (2005) A correction in *Cleistocalyx* (Myrtaceae). *Garden's Bulletin Singapore* 57: 25–27.

Viswanathan, M.B. & Manikandan, U. (2008) A new species of *Syzygium* (Myrtaceae) from the Kalakkad Mundanthurai Tiger Reserve in Peninsular India. *Adansonia* Ser.3. 30 (1): 113–118.

WCSP (2020) *World Checklist of Selected Plant Families*. Facilitated by the Royal Botanic Gardens, Kew. Available from: http://wcsp.science.kew.org (accessed 7 March 2022)

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Chapter 12

Asymmetric Flexible Supercapacitors: An Overview of Principle, Materials and Mechanism

Sabina Yeasmin, Debajyoti Mahanta ✉

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Chao Sun, Jing Zhao, Zhiguang Guo, Yaping Zhao, Zaisheng Cai, Fengyan Ge

ChemElectroChem

Summary

The greatest challenge for researchers is to develop an energy storage system that is sustainable, secure, long lasting and most importantly cost effective. Supercapacitors are considered to be an efficient energy storage device because of their high power density, fast charge–discharge, long cycling life and the environment friendly nature. Flexible solid-state supercapacitors are playing the role of pacesetters in energy storage devices

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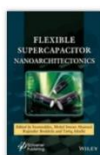
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The 21 chapters in this book presents a comprehensive overview of flexible supercapacitors using engineering nanoarchitectures mediated by functional nanomaterials and polymers as electrodes, electrolytes, and separators, etc. for advanced energy applications. The various aspects of flexible supercapacitors, including capacitor electrochemistry, evaluating parameters, operating conditions, characterization techniques, different types of electrodes, electrolytes, and flexible _... Show all_ ˅

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Chapter 12

Starch and its Derivatives: Properties and Applications

Bhanita Goswami, Debajyoti Mahanta ✉

Book Editor(s):Inamuddin, Mohd Imran Ahamed, Rajender Boddula, Tariq Altalhi

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Polysaccharides: Properties and Applications

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Wheat starch production, structure, functionality and applications—a review

Khetan Shevkani, Narpinder Singh, Ritika Bajaj, Amritpal Kaur

International Journal of Food Science & Technology

Summary

Starch, a natural polymer is an important renewable resource which has attracted significant interest for application in various fields including industrial applications. Native starch as well as modified starch is being increasingly used in many technologies and processes owing to their versatility, biodegradability, cost effectiveness, easy usage and availability. These characteristics of starch and its derivatives result a growing interest towards their application in advanced functional materials including typical

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Polysaccharides: Properties and Applications

Editor(s): Inamuddin, Mohd Imran Ahamed, Rajender Boddula, Tariq Altalhi

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This book provides the whole spectrum of polysaccharides from basic concepts to commercial market applications. Chapters cover various types of sources, classification, properties, characterization, processing, rheology and fabrication of polysaccharide-based materials and their composites and gels. The applications of polysaccharides include in cosmetics, food science, drug delivery, biomedicine, biofuel production, marine, packaging, chromatography and environmental ... Show all ∨

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Leibniz-Institut fur Kristallzuchtung (IKZ)
ORCID: **0000-0003-0888-849X**

Dr Aijaz A. Dar
University of Kashmir
ORCID: **0000-0002-6180-274X**

Professor Junbo Gong
Tianjin University
ORCID: **0000-0002-3376-3296**

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ORCID: **0000-0002-4383-5898**

Dr Ranjit Thakuria
Gauhati University
ORCID: **0000-0002-0325-3316**

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and the snapshot of the excel sheet given below:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
164391 McAllister, Milton M.	The University of Adel	aus	75	1991	2021	227,850	244	8	4.7524	7	18	18	73	33	107	2.5166	160	1.5250
164392 Piedrahita, Jorge	NC State University	usa	119	1985	2020	227,863	350	9	4.2167	5	9	22	68	81	174	2.5166	322	1.0870
164393 Brown, Joshua	University of Pittsburg	usa	68	2009	2021	227,865	540	11	4.1911	0	0	37	243	42	276	2.5166	417	1.2950
164394 Subak, Leslee L.	Stanford University Sch	usa	110	1995	2020	227,867	564	12	5.0931	0	0	21	133	52	262	2.5166	457	1.2341
164395 Manzoni, Pietro	Universitat Politècnica	esp	355	1994	2021	227,874	920	16	6.5560	1	0	19	9	267	727	2.5165	812	1.1330
164396 Petty, Michael C.	Durham University	gbr	396	1976	2021	227,876	341	9	4.9687	15	17	36	24	218	182	2.5165	305	1.1180
164397 Virvou, Maria	University of Piraeus	grc	308	1991	2021	227,878	363	9	5.8667	7	1	84	100	234	327	2.5165	316	1.1487
164398 Li, Qiang	Wuhan National Labo	chn	116	1999	2021	227,881	257	9	4.8742	7	11	27	71	63	130	2.5165	232	1.1078
164399 Thakuria, Ranjit	Gauhati University	ind	45	2008	2021	227,882	380	9	5.7000	0	0	15	239	24	297	2.5165	316	1.2025
164400 Marchal, Francis	Hôpital Universitaire	che	89	1993	2021	227,885	231	9	4.1599	21	10	44	118	58	135	2.5165	143	1.6154
164401 Al-Bayati, Firas A.Y.	University of Leicester	gbr	11	2008	2019	227,889	118	7	4.7769	2	43	6	80	8	98	2.5165	113	1.0442
164402 Papathanasiou, Ioann	University of Thessaly	grc	42	2005	2021	227,892	374	12	3.9628	1	11	7	59	13	94	2.5165	339	1.1032
164403 Rodríguez-González, V	Instituto Potosino de	mex	96	2003	2021	227,894	482	11	5.9190	0	0	22	113	56	306	2.5165	445	1.0831
164404 Luarn, Pin	National Taiwan Univ	twn	29	2003	2021	227,897	380	9	4.8333	0	0	15	279	23	373	2.5165	366	1.0383
164405 Li, Yu Feng	Institute of High Energ	chn	97	2005	2021	227,901	830	13	5.3000	0	0	14	95	31	195	2.5165	742	1.1186
164406 Cui, Yanou	University of Californi	usa	46	2006	2021	227,903	292	9	4.9749	3	6	21	112	24	126	2.5165	236	1.2373
164407 Knight, John	University of Virginia	usa	165	1975	2017	227,907	175	7	4.1444	28	45	71	71	114	100	2.5165	161	1.0870
164408 Zhang, Rong	University of Southam	gbr	109	2007	2020	227,910	511	13	6.8190	0	0	37	126	37	126	2.5165	390	1.3103
164409 Chardot, Christophe	Hôpital Necker Enfant	fra	111	1994	2021	227,913	393	10	4.0221	5	10	20	59	45	143	2.5165	324	1.2130
164410 Zhang, Lei	Shaanxi University of S	chn	22	2016	2021	227,917	439	13	3.4651	0	0	7	292	9	294	2.5165	231	1.9004
164411 Griem, H. R.	University of Maryland	usa	196	1953	2007	227,923	158	6	4.0000	33	53	57	77	137	126	2.5165	120	1.3167
164412 Gutleb, Arno C.	Luxembourg Institute	lux	123	1995	2021	227,927	750	14	4.8173	2	1	19	54	37	186	2.5164	696	1.0776
164413 Roses, Marti	Universitat de Barcelo	esp	158	1987	2021	227,929	471	8	5.9619	5	3	18	64	93	226	2.5164	355	1.3268
164414 Gillery, Philippe	Université de Reims C	fra	246	1980	2021	227,932	383	8	5.8226	17	9	59	33	151	203	2.5164	307	1.2476
164415 Park, Woon Bae	Sunchon National Uni	kor	59	2010	2021	227,937	443	12	4.2222	3	1	22	174	23	174	2.5164	343	1.2915
164416 Dutta, Raj Kumar	Indian Institute of Tec	ind	58	1997	2021	227,938	352	10	6.8667	0	0	25	139	40	286	2.5164	336	1.0476
164417 Kang, Tae Wook	SKKU School of Medici	kor	117	2007	2021	227,940	635	12	4.8474	0	0	30	185	32	185	2.5164	499	1.2725
164418 Minneci, Peter C.	Nationwide Children's	usa	174	1998	2021	227,947	633	11	5.1285	1	0	37	128	77	290	2.5164	550	1.1509
164419 Kritzer, Peter	Freudenberg Vliesstof	deu	20	1997	2004	227,952	117	6	3.8333	3	54	15	117	16	117	2.5164	93	1.2581
164420 Thompson, Laurence K	Memorial University o	can	259	1971	2021	227,953	343	7	4.8385	6	10	31	68	118	279	2.5164	254	1.3504
164421 Eckstein, Martin	Friedrich-Alexander-U	deu	101	2005	2021	227,954	536	11	6.1310	0	0	19	103	57	279	2.5164	331	1.6193
164422 Strauss, Keith J.	University of Cincinnat	usa	93	1994	2021	227,955	343	10	4.7724	14	7	29	77	43	120	2.5164	293	1.1706
164423 O'Leary, Stephen K.	University of British Cc	can	119	1992	2021	227,956	231	7	4.7833	5	13	28	87	97	174	2.5164	165	1.4000
164424 Bruderer, Bruno	Swiss Ornithological I	che	71	1972	2018	227,959	191	8	4.8667	8	12	33	78	69	185	2.5164	116	1.6466
164425 Taylor, Brent C.	VA Medical Center	usa	167	2004	2021	227,961	1,122	16	5.8856	0	0	10	78	17	87	2.5164	1,003	1.1186
164426 Liu, Gang Logan	Huazhong University o	chn	158	2003	2021	227,967	575	13	5.9394	3	0	21	73	101	279	2.5164	515	1.1165
164427 Tham, Clement C.	Chinese University of	hkg	188	1997	2021	227,972	888	14	5.9899	5	0	35	67	64	166	2.5164	701	1.2668
164428 Zhaqilao	Inner Mongolia Norma	chn	34	2008	2021	227,974	108	5	4.5000	14	77	26	93	34	108	2.5164	88	1.2273
164429 Li, Dapeng	Liaoning University of	chn	17	2015	2021	227,976	417	11	4.0833	0	0	8	249	14	366	2.5164	317	1.3155
164430 Fleming, Jennifer	The University of Quee	aus	228	1994	2021	227,986	749	10	6.9512	2	0	26	99	65	190	2.5163	521	1.4376
164431 Parah, Shabir A.	University of Kashmir	ind	72	2010	2021	227,995	453	13	4.1833	0	0	23	233	29	237	2.5163	369	1.2276
164432 Lin, Haili	Huaibei Coal Industry	chn	71	2005	2021	227,996	771	16	6.0595	0	0	16	95	17	95	2.5163	633	1.2180
164433 Li, Yefei	Xi'an Jiaotong Univers	chn	109	2008	2021	227,997	577	13	5.0401	0	0	21	154	35	188	2.5163	490	1.1776
164434 Kumar, Santosh	Konkuk University	kor	135	1973	2020	227,999	428	11	5.0147	1	0	58	231	76	240	2.5163	386	1.1088
164435 Gray, Andrew N.	USDA ARS Corvallis For	usa	66	1995	2021	228,001	271	9	4.8560	4	7	21	92	39	151	2.5163	245	1.1061
164436 Chung, Jae Dong	Sejong University	kor	112	1996	2021	228,004	478	12	7.3167	3	0	20	60	74	293	2.5163	409	1.1687
164437 Telem, Dana	University of Michigan	usa	95	2008	2021	228,008	413	11	4.8017	2	1	30	125	49	237	2.5163	380	1.0868
164438 Yuan, Wu	Chinese University of	hkg	71	2006	2020	228,016	248	9	4.4433	3	10	30	113	30	113	2.5163	210	1.1810

Article

Consanguinity: A Form of Social Capital Among the Muslims of *Char* Areas in Barpeta District, Assam

Gulrukh Begum[1] ⓘD

Abstract

Information on the dynamics of consanguinity is always important for public health strategy. It provides a direct roadmap for healthcare providers and health policymakers to make people aware of the consequences of consanguinity. The present study aims to investigate the attitude of the Muslim people practising consanguinity in the *char* (river island) areas of Barpeta district in Assam. It intends to seek a cultural explanation behind the practice of consanguinity.

The study was conducted cross-sectionally among the Muslims living in different villages of the temporary, semi-permanent and permanent river islands of Barpeta district in Assam. A total of 556 married couples were included in the study. Of these, 103 couples are consanguineous and the rest 453 are non-consanguineous. To study the prevalence of congenital disorders, a sample of 153 males and 121 female inbred children of the consanguineous couples and 701 male and 571 female children of the non-consanguineous parents have been included in the study.

The prevalence of consanguineous marriage in the *chars* was found to be 18.53% and the average coefficient of inbreeding was 0.05996796. Of the consanguineous marriages, the most favoured type was between the first cousins (63.11%), followed by half first-cousin marriages (12.62%). Altogether 14.60% of inbred were found to have some type of congenital disorder against 0.31% non-inbred. In the *chars* of Barpeta, it is not only ignorance but poor economic condition is also a reason behind the practise of consanguinity. Consanguineous marriage provides means of escaping the expenditure incurred in dowry or bridewealth payment. With seasonal floods, river erodes their village and crops completely every year. Family remains the sole source of stability and security. Consanguineous

[1] Department of Anthropology, Gauhati University, Guwahati, Assam, India.

Corresponding author:
Gulrukh Begum, Professor, Department of Anthropology, Gauhati University, Guwahati, Assam 781014, India.
E-mail: gulrukhbegum@gauhati.ac.in

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A study on high-risk Human Papilloma Virus (HPV) types 16 & 18 infections among the women of the Barak Valley in Northeast India

Pritam Das[1], Gulrukh Begum[2], Sunil Thakur[3], Pulakes Purkait[4], Dipneet Kaur[4]

[1,2]Department of Anthropology, Gauhati University, India, [3,4]Origin LIFE Healthcare Solutions and Research Centre LLP, Chandigarh, India; Corresponding author: Pritam Das <pritam10das.pd@gmail.com >

KEYWORDS	ABSTRACT
HPV type 16 and 18, viral infection, cervical cancer, women, Assam	Despite India has a high incidence of cervical cancer, there aren't enough large-scale population-based investigations on the prevalence and genotype distribution of the Human Papilloma Virus (HPV). Out of the several high-risk types, HPV-16 and HPV-18 are primarily responsible for the bulk of cancers linked to the virus. The present study investigates the genotype distribution of HPV-16 and HPV-18 with respect to cervical cytology among the women of the Barak Valley, Assam, Northeast India. A total of 80 women were enrolled in the study. After the enrolment of the participants, cervicovaginal smears were collected and processed for (a) HPV genotyping and (b) cytological analysis. HPV DNA detection was done with consensus primers MY09/11, followed by the detection of HPV-16 and HPV-18 with type-specific primers. Liquid Based Cytology (LBC) test was performed, and cytological grading was done. Overall HPV prevalence was 17.5% (14/80) using MY09/11 HPV consensus primers. HPV-16 is found to be the most prevalent single infection (8.75%, 7/80), followed by HPV-18 (6.25%, 5/80). When co-infection with HPV types 16+18 is found to be 2.5% (2/80). In cytological analysis, a total of 10% (8/80) show abnormal lesions in various cytological categories. The distribution of abnormal cytological lesions is CIN1 (6.25%, 5/80), CIN2 (2.5%, 2/80), and CIN3 (1.25%, 1/80). When HPV infection was checked across different cytological categories, 87.5% (6/8) of abnormal cytological lesions were HPV positive. The present study found that overall HPV infection is high among the women of the Barak Valley Northeast India. Awareness about the virus, information on available screening methods, and vaccination may play a decisive role in reducing the infection rate.

Introduction

HPV is a group of sexually transmitted viruses consisting of more than 200 types in their viral family. Nearly all sexually active individuals are infected with HPV instantly after becoming sexually involved and engaged. Approximately half of these infections are with a high-risk HPV type. The types of HPV that are sexually transmitted fall into two broad groups: low-risk and high-risk. Mostly, low-risk HPVs do not cause any illness. However, a few low-risk types of HPV cause warts on or around the penis, anus, mouth, or throat. High-risk HPVs may cause several forms of cancer (Cobos et al., 2014). Around 14 high-risk forms of HPV occur. Two of these, HPV16 and HPV18, are primarily responsible for the bulk of cancers. And almost all cervical cancers are reported to be linked with high-risk HPV types (American Cancer Society, 2020). Recent research indicates that HPV infection can affect fertility (Souho et al., 2015). Sperm with HPV infection can transmit viral DNA to oocytes, manifested in the developing blastocyst. HPV can increase trophoblastic apoptosis and decrease trophoblastic cells'

Relation of Obesity and Hypertension Among Elderly Karbis of Karbi Anglong, Assam

Chandana Sarmah

*Department of Anthropology, Gauhati University, GNB Nagar,
Guwahati 781 014, Assam, India
E-mail: chandanasarmah@gauhati.ac.in*

ABSTRACT Worldwide there is increasing incidence of obesity. Obesity and hypertension are interrelated and result from changes in body composition and lifestyle factors concomitant to age. The present study examines the prevalence and relation of obesity and hypertension among elderly Karbis following a traditional way of life in the hill district of Karbi Anglong, Assam. The sample of the study consists of 335 male and female elderly (60 years and above) Karbis. Whole body obesity and abdominal obesity are assessed from anthropometric variables, indices and fat percentage. Hypertension is categorised according to the WHO classification of systolic and diastolic blood pressure used in estimating risk for metabolic syndrome. Prevalence of obesity by fat percentage is higher. Abdominal obesity and hypertension prevalence is higher in elderly female in comparison to elderly male. Hypertension prevalence is influenced significantly by fat percentage in both male and female elderly and by Waist Circumference in male elderly.

INTRODUCTION

Obesity is recognised as a major public health problem in both developed and developing countries. Obesity is often defined as a condition of abnormal or excessive fat accumulation in adipose tissue, to the event that health may be impaired (WHO 2000). Obese individuals differ not only in the amount of excess fat they store, but also in the regional distribution of fat within the body. Fat accumulation is also affected by age as body composition undergoes change and fat gets redistributed and accumulates around the abdominal region. Fat accumulation in the abdominal region puts people at risk for various metabolic disorders. Obesity prevalence among the elderly population from marginalised tribal communities has not been studied in the northeast Indian context. Studies on nutritional status among tribal elderly people from the region have reported higher prevalence of under nutrition and some proportion of over nutrition (Das and Sarmah 2015; Sarmah 2019). Elderly people can face the dual burden of under nutrition and over nutrition as found in the studied societies.

Obesity predisposes an individual to a number of cardiovascular risk factors including hypertension, raised cholesterol and impaired glucose tolerance. It is also one of the criteria for identifying metabolic syndrome. Excess body fat in addition to being a significant contributor to disease risk also varies between individuals by age, sex, region, socio-economic condition and ethnicity. Among elderly population excess body fat, age and other environmental factors may be significant in increasing disease risks.

One of the conditions, which arise out of obesity, is hypertension. Hypertension results from changes in the cardiovascular system with age. Structural changes taking place in the cardiovascular system brings about a decline in the functional capacity of the circulatory system resulting in higher blood pressure levels with age. This dynamic physiological measure is influenced by both biological and socio-cultural factors. It is influenced by various factors like climate, degree of urbanisation, work schedule, activity pattern and dietary habits (Bassey 1992). Blood pressure shows greater relation with age among people living in modern urbanised economies than people living in cultures following traditional beliefs and values (Waldron et al. 1982).

In developing countries hypertension is found to exist in a background of under nutrition (Tesfaye et al. 2007). Moreover, Body Mass Index (BMI) is significantly and positively correlated with both SBP and DBP in some populations. Studies have shown that higher BMI is associated with hypertension (Dua et al. 2014; Wang et al. 2014; Babu et al. 2018; Hossain et al. 2019). Similar association is not understood to the desired extent among elderly in rural or tribal context in

Understanding Soanian occurrences at Bam locality of Siwalik frontal range, north-western India

Worrel Kumar BAIN[1]*, Dwipen BEZBARUAH[1]

[1]Department of Anthropology, Gauhati University, Gopinath Bardoloi Nagar, Jalukbari, Gauhati, Assam 781014, India

Abstract Paleolithic evidence of the Indian subcontinent is often expressed through the wealth of lithic antiquities from the Stone Age. In this region, the earliest known lithic remains comprise simple cores and flakes recovered from the Siwalik Hills. The Siwalik Hills are the foothills of the southern edge of the Himalayas, and area goldmine zone for Soanian lithic implements. Although Acheulean remains have also been reported, their occurrences are few. Nevertheless, these remains have been known date from the Pleistocene, which shows varied patterns of land use and intraregional versatility. In the Siwalik Hills, Soanian implements are of two kinds: (i) a chopper type of the Lower Paleolithic period and (ii) a flake type belonging to the Middle Paleolithic period. The present study was undertaken at a newly discovered Stone Age locality, Bam, located within the frontal range of the Siwalik Hills in the Bilaspur district of Himachal Pradesh, India. The area under study plays an important role in understanding the relationship between people and land. The paper explores the Soanian cultural remains of the site to obtain an in-depth understanding of its nature against the backdrop of raw material availability and exploitation. The study also throws light on the local geological and geomorphological settings of the area.

Key words: Siwalik Hills, Bam, Geomorphology, Soanian, Raw material exploitation

Introduction

The Indian Himalayan ranges cover the states of Jammu and Kashmir, Uttrakhand, Himachal Pradesh, Arunachal Pradesh, Sikkim, Assam, and the hilly areas of West Bengal, and comprise three segments: (i) the higher Himalayas toward the Tibetan plateau, (ii) the lesser Himalayas, and (iii) the sub-Himalayas. The higher Himalayas are formed from metamorphic rocks and magnetic rocks. Grades of metamorphic rocks with intrusions of amphibolites, stones, pegmatites (generally crystalline rocks or various volcanic stones with a few centimetres of crystals), and quartz constitute the lesser Himalayas (Abdessadoka et al., 2016). As indicated by Mohapatra (2007), lithologically and ecologically the sub-Himalayas comprise three zones: (i) the Siwalik frontal range (abruptly transcending and flanking the Indo-Gangetic plains); (ii) the Duns (a progression of flat-bottomed longitudinal structural valleys with well-developed terraces); and (iii) the lesser Himalayas piedmont against which abut the terraces of the Duns. The Siwalik Hills comprise a 2400 km long stretch. They stretch from the Potwar plateau region of Pakistan to the north-eastern part of India and onto Myanmar, the south-western Himalayan frontier (Figure 1).

Geologically, the Siwalik Hills show sediments of natural freshwater molasses accumulated in a long narrow foredeep. They formed to the south of the rising Himalayas, and had their origins in the third and most dramatic uplift during the Middle Miocene to Middle Pleistocene. Structurally, the Siwalik Hills were folded, and over thrust toward the south by the Lower Tertiary formations (Tripathi, 1986). The foreland basin of the Siwalik Hills comprises fluvial deposits (Chauhan, 2009). It is an active collisional foreland basin system that covers five nations, i.e. India, Nepal, Pakistan, Bhutan, and Bangladesh, with a width of 450 km (280 miles) and a length of 2000 km (1200 miles) (DeCelles, 2012). Records of sedimentary rocks accumulated in the more extensive Himalayan territory encompassing India and Nepal go back to the underlying creation of the foreland basin. It began around 45–50 million years ago in the Paleogene time when the Indian and Asian plates crashed together. The stratigraphic progression of the basin is remarkable as it maintains and identifies with the Himalayan orogenesis. It is the proof of the collision between the Indian and Eurasian plates. The significance of the Siwalik foreland basin's stratigraphy is unrivalled because of its role throughout geographical time in the development of the basin. This basin comprises fluvial dregs kept by hinterland rivers streaming southwards and south-westwards (Gill, 1983; Chauhan, 2009, 2010) from the lesser and greater Himalayas when the south area of these mountains were initially a basin (Brozovic and Burbank, 2000). Stratigraphically the deposits of

* Correspondence to: Worrel Kumar Bain, Department of Anthropology, Gauhati University, Gopinath Bardoloi Nagar, Jalukbari, Gauhati, Assam 781014, India.
E-mail: worrel.bain@gmail.com

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CONTENTS

Nutrition Security among Karbis of Kamrup District of Assam

Goswami RG and Thakur MB

Abstract

Food security means availability and access to food to all individuals throughout the year whereas nutrition security means the food which is available should provide the essential nutrients as per individual requirements. A study was conducted to assess the dietary intake and nutritional status of Karbi tribe of Kamrup district of Assam. The study covered 400 women of Chandrapur and Dimoria block of Kamrup district in the age group of 15 to 49 years. Sample selection was done by using purposive random sampling method. Dietary intake was assessed by using 24-hour recall method and Body Mass Index was determined by measuring the height and weight by using standard procedures. The study revealed that the Karbis included cereals, pulses and flesh foods and green leafy vegetables every day in adequate amounts in their meals which are the major sources of macro and micronutrients. Flesh foods which were included in the dietary every day were fresh fish, dry fish and meat which meet the protein requirement among the Karbis. Carbohydrate intake may be mentioned as adequate as adequacy level of cereals ranged from 103 per cent to 116 per cent which was more than the RDA given by ICMR (2011). Similarly, the micronutrients intake was good as green leafy vegetables and other vegetables were included every day and adequacy level of leafy vegetables ranged from 106 per cent to 112 per cent which was also more than the recommended RDA. The use of herbs as green leafy vegetables among the Karbi dietary help to increase immunity to the body. Karbi dietary was adequate and this is revealed by the fact that very less (15.25 %) number of respondents was underweight. And none of the respondents were moderately underweight (<17.0) or severely underweight (≤ 16.0). Majority (75 %) of adult women of the studied area were having normal nutritional status (BMI between 18.5 to 24.99). The study concluded that the nutrition security was much better among the Karbi population of Kamrup district of Assam as the prevalence of undernutrition was very less in comparison to other tribal groups of India.

Keywords

Anthropological Interface between the Hills and Plains: An understanding from Assam –Meghalaya Border Region

[1]*Smita Devi Bora* & [2]*Dwipen Bezbaruah*

Abstract

Traditional practices are always informative and can be used as a tool to reconstruct the past culture. In many societies of Northeast India such kind of practices still continue to exist and which had many elements passed on from ancestral generation. The Assam- Meghalaya border area towards the southern part of Kamrup district of Assam is inhabited largely by Khasi, Garo, Karbi and few other caste populations. The subsistence pattern, economic as well as socio-cultural practice and geomorphological location of the region drew attention which leads to exposure of many significant ethnographic and archaeological data. In Assam –Meghalaya border region, there is the prevalence of traditional market system, where there is the evidence of age old practice of barter exchange in the form of Basket exchange, especially by the women, locally known as Hora Solua. Prolific occurrence of ceramic sherds of which the reconstructed versions show close resemblance with respect to shape and size with the utensils used by the present day inhabitants. Erection of megaliths in the memory of deceased clan members has raised the anthropo-archaeological significance of this area. In order to have a comprehensive understanding of the area the researcher tried to analyse the findings from the ethno-archaelogical perspective. The present study reveals that though the culture under study is chronologically modern but economically and anthropologically they are Neolithic or may be later.

Keywords: *Trade, Pottery, Megalith, Ethno-archaeology, Tradition*

Introduction

Trade is always been a fascinating and engrossing affair for anthropologists as it can give an insight about the economic condition of the society. Trade can be defined as the "mutually appropriate movement of goods between hands" (Renfrew 1975). Apart from economic condition it can provide information about socio-cultural practices, the changes that happened within it and interregional contact over time. Many such studies done on trade and exchange of stone, ceramics and metals in Europe, especially in the Mediterranean region, Near east and North America reveal important information about their raw material procurement, fashioning techniques and socio-economic condition of the society. Trade is recognized in archaeological record by the discovery of objects

Subsistence Agriculture and Traditional Food Preservation Methods among the Ethnic Communities of Northeast India

Smita Devi Bora[*]

Abstract: Food, shelter and cloth are the three basic necessities for survival. At the early stage of human evolution, man was very much dependent on nature for survival. But with the passage of time they attained some control over the environment which resulted in a shift from the food gathering stage to a food producing phase. At the start of the food producing stage an incipient shifting form of cultivation with simple tools came into practice. With food production, a new concept i.e. food storage and preservation, emerged to take care of surplus production or future consumption. The archaic method of cultivation was also practiced by the ethnic communities residing in the hilly regions of Northeast India. During the course of exploration near the Assam–Meghalaya border evidence of this type of cultivation commonly known as shifting or jhum cultivation has been reported. This study sees the various associated aspects of shifting cultivation as subsistence agriculture and also outlines the three causes which lead to such practice by the ethnic communities near the Assam–Meghalaya border area towards the south-eastern periphery of Kamrup district in Assam. The study also showed preservation of surplus crops through various conventional methods like drying, smoking, salting, fermenting, pickling and sugaring to consume in lean periods. From the data gathered for this research, it is argued that this cultivation system is a survival strategy in socio-political, economic and ecological terms. The practice is deeply rooted not only in their culture but also as a way of life. An aspect of ethno nationalism among the population is also implicit in its continuation despite various government interventions against the system. Further it is suggested that, introduction of cash crops and terracing of the plot can convert this farming system into a permanent one and provide a more sustainable and eco-culturally friendly practice.
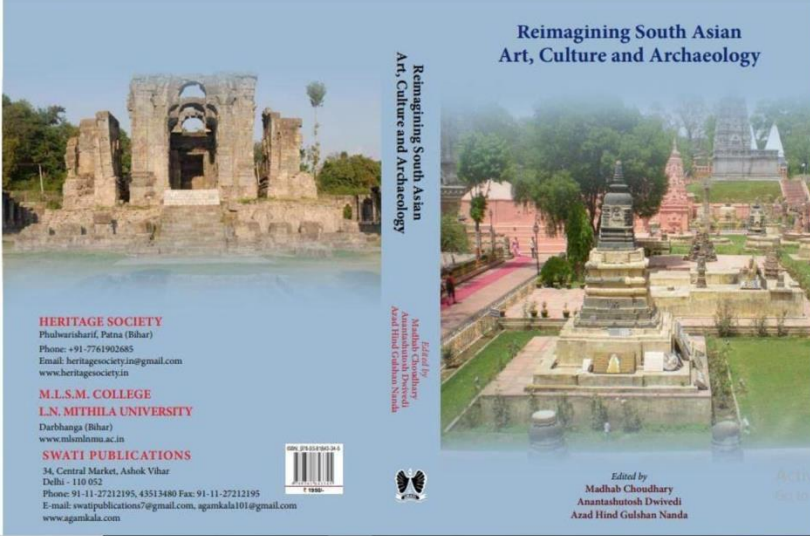
Keywords: Subsistence, Preservation, Shifting Cultivation, Identity, Sustainable.

[*] Assistant Professor, Department of Anthropology, Gauhati University

Madhab Choudhary is at present working as Professor and Head of the P.G. Department of History, L.N. Mithila University, Darbhanga. He holds a doctorate degree in Modern Indian History. His academic career is studded with several distinctions. He has participated and presented research papers in several national and international Seminars. He has deep academic links with many associations working in the field of History. At present, he is also an executive member of MITHILA ITIHAS SANSTHAN, Darbhanga.

Anantashutosh Dwivedi is presently engaged as Director-General at Heritage Society, Patna. He is also serving as Director at the Archaeological Exploration and Excavation Department, Heritage Society. He was awarded a Ph.D. degree from Patna University on *Socio-economic milieu of Stone Sculpture in Bihar*. He has been closely associated with the Archaeological Survey of India and has been involved in several archaeological projects such as excavations at Juafardih, Ghorakatora, Chausa, Kutumba, and explorations in different districts of Bihar. Prior to joining at Heritage Society, he has worked at K.P. Jayaswal Research Institute, Directorate of Museums, and Bihar Virasat Vikas Samiti, Government of Bihar, in his various capacities. Recently, he has excavated Lari, an early historic archaeological site in the Arwal district of Bihar. He has organized numerous seminars, workshops, and lectures and has presented research papers therein. Some of his research papers have been published in referred national and international journals. He has also been attached to many research academies too. His interest lies in the field of public archaeology.

Azad Hind Gulshan Nanda is presently serving as a Director at the Buddhist Heritage Research Institute, Heritage Society. Prior to joining at Heritage Society, he worked as Project Coordinator in the Rajgir Archaeological Survey Project at Nalanda University, Rajgir. He has earlier held fellowships at ISEAS-Yusof Ishak Institute (Singapore), Universitas Sebelas Maret (Indonesia), and Nalanda University (India). He has received travel grants from EPHE (Paris) and SOAS (UK) to attend field schools in Southeast Asia. His research interests include the archaeology of ancient Indian cities, Buddhist art and heritage, and the comparative study of cultural exchanges in South and Southeast Asia. He has presented his research papers at several conferences and has published his academic works in reputed national and international journals.

Reimagining South Asian Art, Culture and Archaeology

Edited by
Madhab Choudhary
Anantashutosh Dwivedi
Azad Hind Gulshan Nanda

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Azad Hind Gulshan Nanda

The Book

This edited volume contains ten original research papers and essays on various aspects of South Asian art, culture, and archaeology. The authors address the broad issues of trans-disciplinarity and cultural complexity attested with the art and archaeological practices of South Asia. It opens with a serious discussion on fundamental issues of archaeology and suggests effective ways that would reframe the archaeological methods of the future. The focus shift from the monument-centric approach to a collaborative trans-disciplinary endeavour eventually reconceptualizes archaeology as integrated into other disciplines. The voluminous rise in archaeological data generated through more sophisticated scientific equipment testifies the close collaboration of archaeology with science. The study of cultural sequence, urbanisation pattern, and contextual analysis of material objects with nearby sites emerging more as a recent trend projects a novel research trajectory of moving away from the conventional norms of disciplinary studies and thereby adopting inter-disciplinary perspective in art-cultural studies.

This book includes some preliminary reports of recent explorations and excavations conducted in Vangchhia (Mizoram) and Ganaur (Haryana). The report highlights the huge distribution of menhirs, petroglyphs, potteries, burial sites, and sculptural fragments all around Mizoram, thereby outlying the distinguish presence of Vangchhia culture. The volume also builds new perspectives to study the stylistic patterns, artistic developments, architectural expansion, and cultural complexity through the site-specific study. These studies focus on site-specific empirical research and demonstrate trans-disciplinarity and inter-disciplinary orientation of research in ancient South Asian studies.
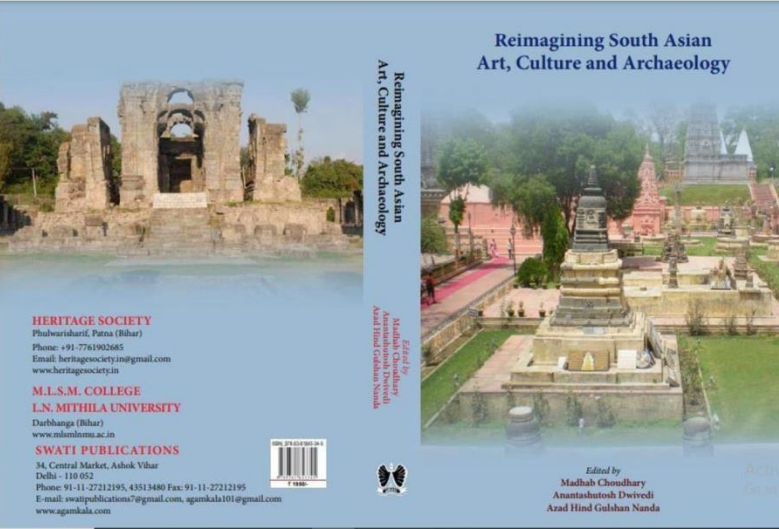

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Contents

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Practices, Perspectives and Policies

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Development of Opto-Mechanical Method to Measure Liquid Volume, Density, and Level

Nityananda Hazarika, Ram Kishore Roy ✉, Munmee Borah, Hidam Kumarjit Singh & Tulshi Bezboruah

Conference paper │ First Online: 01 November 2022

384 Accesses

Abstract

We demonstrate here an optical method, capable of measuring liquid volume, level, and density by using linear extension spring. This measurement method is based on linear extension of vertically suspended helical spring with a light source fixed on the top end and a light-dependent resistor on the bottom end of the spring, both being in same alignment. Loading liquid samples in a cylindrical container attached to the bottom end of the spring results in corresponding elongation in length of the spring, thereby changing the longitudinal distance between light source and light-dependent resistor. Light intensity is proportional to the square of the distance from the source; hence, resistance of the light-dependent resistor changes accordingly.

Keywords

Light intensity   Linear extension spring   Longitudinal distance

Optical method   Volume measurement   Level measurement

Density measurement

Investigation on Measurement of Liquid Volume by using Bend Sensor and Linear Extension Spring

Nityananda Hazarika
Department of Electronics &
Communication Technology
Gauhati University
Guwahati, India
hazarikanitya@gmail.com

Ram Kishore Roy
Department of Electronics &
Communication Technology
Gauhati University
Guwahati, India
r.kore51guece@gmail.com

Hidam Kumarjit Singh
Department of Electronics &
Communication Technology
Gauhati University
Guwahati, India
kumarjit_hidam@yahoo.com

Tulshi Bezboruah
Department of Electronics &
Communication Technology
Gauhati University
Guwahati, India
zbt_gu@yahoo.co.in

Abstract— In this paper, we report the investigation on measurement of liquid volume by using bend sensor and linear extension spring. The bend sensor is mounted in U-shaped laterally to a vertically suspended spring. A liquid container is attached to the bottom end of the spring. As the volume of the liquid in the container changes, the elongation length of the spring also gets changes. There will be corresponding changes in the bending radius of the mounted bend sensor. The changes in bending radius will introduce changes in resistance of the bend sensor. A resistance to frequency conversion signal processing circuit is used to convert the changes in resistance to frequency counts. Further, the output of signal processing circuit is processed by a microcontroller. The resolution in measurement is found to be within the range of 3.9-12.6 μL. The advantages of the propose system is that the measurement of liquid volume is independent of refractive index or colour of the liquids and also can be used for volatile liquid.

Keywords—bend sensor, liquid volume, extension spring, bending radius and resistance to frequency converter.

I. INTRODUCTION

Traditionally, volume of a liquid is measured by using graduated cylinders, beakers or liquid measuring cups [1]. But measurement of volume of liquid with traditional methods are time consuming and error-prone. Modern biochemical and pharmaceutical laboratories or industries demand quick, automated and precise measurements of volume of the liquid products. In order to meet those demands, researchers have proposed and reported several non-conventional sensing methods for the measurement of liquid volume. Most of the common sensing methods that are reported on the literature are based on the principles of fiber optics [2]. Fiber optic sensors provide several advantages [3], however measurement is limited to liquids having certain refractive indices, colours or optical spectra only. Microwave resonator-based sensing also draws research interest in the measurement of liquid volumes [4], [5]. The gravimetric method is also considered useful in accurate determination of liquid volume up to sub-microliter range [6]. The spring-based sensing methods due to its high reproducibility are gaining attention among researchers, reported in [7], [8].

In the proposed method, we have used extension spring attached with bend sensor (BS) as electro-mechanical sensor for the measurement of liquid volume. The system has advantages in its simplicity of design and inexpensive signal processing components. Further, the frequency output of signal processing circuit (SPC) is process by microcontroller (μC) without the need of analog-to-digital conversion circuit.

II. SENSING PRINCIPLE OF THE PRPOSED METHOD

The sensing principle for the measurement of liquid volume is shown in Fig.1. A linear extension spring is vertically suspended over a fixed rigid clamp. A BS is attached laterally to the spring in U-shape covering a definite number of active coils of the spring within its curvature. The sensor is fabricated by polyester or fiber glass with carbon-impregnated layer deposited in-between [10]. The sensor shows variation in its resistance due to change in bending radius or mechanical deformation.
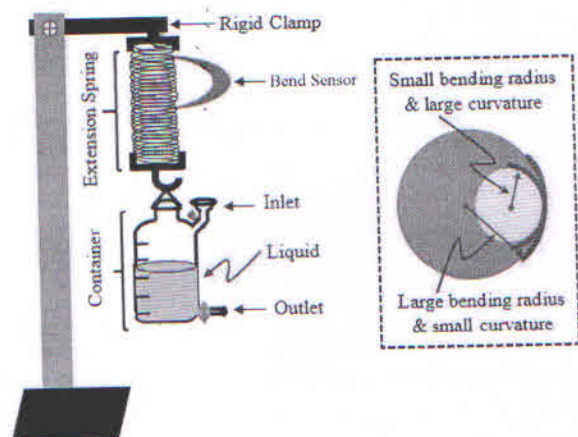

Fig.1. Schematic diagram of the sensing principle (in inset it shows relationship between bending radius and curvature of bend sensor).

The free end of the spring is attached to a liquid container. When the volume of liquid in the container changes, the elongation in the length of the spring will also

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Abstract:

This work illustrates in detail the design implementation of a temperature controller needed for a viscosity measurement system. The system allows the user to heat and cool a closed glass chamber to a desired temperature of measurement. A single thermoelectric module of 6A is used to achieve the desired task. A negative temperature coefficient temperature sensor, connected to an Arduino UNO board is used to monitor the temperature inside the chamber. A relay module connected to the Arduino board is used to control the thermoelectric module to maintain the chamber's desired temperature. A Windows-compatible graphical user interface has been developed to control, read and store the real-time data. The temperature maintained by the chamber is almost stable around the set temperature. The system works well in the temperature range of 20°C - 40°C when the ambient temperature is about 27°C. The temperature range varies depending on the change in the ambient temperature of the surrounding area.

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Parasitic Antennas for Current and Future Wireless Communication Systems: Trends, Challenges, and Emerging Aspects

Roktim Konch ✉, Sivaranjan Goswami, Kumaresh Sarmah, Kandarpa Kumar Sarma & Nikos Mastorakia

Chapter │ First Online: 03 February 2022

579 Accesses

Abstract

In recent years, parasitic element-based designs have been found to play important roles in smart and adaptive systems and are the subjects of recent developments. They offer several advantages such as multifunction capabilities, minimized volume requirements, beam diversity, frequency reconfigurable, and ultra-wideband application. This makes them well-suited for wireless application such as fifth generation (5G) and subsequent generations of mobile terminals. With the employment of active material microelectromechanical systems (MEMS), varactor, or PIN diodes, an antenna's characteristics are often changed through alternating the flow of current on the antenna structure. If an antenna is to be reconfigurable in many different states, it needs to have an adequate number of active and passive elements. However, a large number of high-quality active elements increase the cost of the overall system in terms of the required number of transmitters, amplifiers, and other associated electronic components. Introducing reconfigurable intelligent surface and investigating its characteristics

Chapter

SIMULATION-DRIVEN OPTIMIZATION OF SLOT ANTENNA USING GENETIC ALGORITHM

Sivaranjan Goswami[*1], *Kumaresh Sarmah*[2], *Kandarpa Kumar Sarma*[3*]

[1, 3]Department of Electronics and Communication Engineering, Gauhati University, Guwahati, Assam, India
[2]Department of Electronics and Communication Technology, Gauhati University, Guwahati, Assam, India

Abstract

Ansys Electronics Desktop (AEDT), formerly known as Ansys HFSS, is one of the most widely used software packages for the design and analysis of antennas for microwave applications. AEDT is powered by a 3D full-wave finite elements method (FEM) solver. It is equipped with a user-friendly interface that enables designing antennas graphically. This approach, however, is not convenient for algorithmic tuning and optimization of antennas. The Optimetrics tool is available only helps in sweeping a few physical dimensions of the antenna over a pre-defined range and compute some output parameters based on the simulation results. As the number of dimensions to be optimized increases, there is an exponential increase in the number of simulations to be performed. AEDT also provides a script interface where antennas can be designed programmatically by writing scripts in either Python or VB Script. Python, in recent years, has emerged as one of the most powerful languages for technical computation. AEDT, however, comes with Iron Python, which lacks supports for many essential packages making it challenging to implement any computational algorithm. An implementation of the genetic algorithm for Iron-Python is presented in this paper that can be used for optimizing antenna structures within AEDT. An H-shaped slot antenna is optimized with this technique. The optimized antenna is fabricated and validated from measured result.

[*]E-mail address: [1]sivgos@gmail.com, [2]kumaresh@gauhati.ac.in [3]kandarpaks@gauhati.ac.in
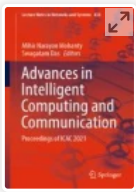
Advances in Intelligent Computing and Communication pp 339–345

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Metamaterial CSRR Loaded T-Junction Phase Shifting Power Divider Operating at 2.4 GHz

Kumaresh Sarmah ✉, Roktim Konch & Sivaranjan Goswami

Conference paper | First Online: 17 May 2022

173 Accesses

Abstract

A power divider T-network requires dissimilar lengths of the two output branches if a phase difference is desired between the two output ports. This often leads to an asymmetrical structure of the power divider. In this paper, a phase difference between the two output ports of a power divider is achieved with the help of a complementary split-ring resonator (CSRR) structure. The T-junction divider is a three-port network. The middle port is fed by a 50 Ω microstrip line, and the other two ports are considered as an output port. A CSRR is etched from the ground plane below one of the output branches. It is observed that by adjusting the position of the CSRR structure in a company with a microstrip line, it is possible to modify the phase variation between output branches and this divider additionally having less power loss characteristics. A design prototype is fabricated in an FR4 substrate and tested at a frequency 2.4 GHz for a phase modification of about 45°. The proposed power divider is compact and simple in design and less power losses so it is easily integrated with microstrip antennas and convenient for phased array antenna design.

An Antipodal Vivaldi Antenna Array with Modified Ground Plane and Slotted Radiators for 5G Millimeter-wave Applications

Innocent Kadaleka Phiri
Department of Electronics and
Comunication Engineering,
Gauhati University, Assam, India
innocentkphiri@gmail.com

Kumaresh Sarmah
Department of Electronics and
Comunication Technology,
Gauhati University, Assam, India
kumaresh@gauhati.ac.in

Abstract—An antipodal Vivaldi antenna (AVA) array for fifth generation (5G) millimeter-wave (mm Wave) applications is proposed in this paper. Initially, a single element AVA is designed. Then an array with 4 × 1 AVA elements and a 3-dB power divider is designed on an FR-4 epoxy substrate of size 28 × 32 × 1.6 mm^3. Inclusion of cuts on antenna radiators improves the operating bandwidth of the array antenna. Structural modification on the feeding section of the ground plane improves impedance matching (S11), operating bandwidth and gain of the array antenna. The array antenna is designed using High Frequency Structure Simulator (HFSS). Overall operational bandwidth of the array antenna is between 22.8 – 29.1 GHz (S11 < −10 dB) covering the *n257* & *n258* 5G mm Wave band. The designed array antenna shows maximum gain of 8.1 dB.

Keywords—Antipodal Vivaldi Antenna (AVA), antenna array, 5G millimeter-wave (mm Wave), power divider, slot cuts, high gain.

I. INTRODUCTION

The present fourth generation (4G) mobile wireless communication is facing challenges of spectrum shortage and moderate capacity [1]. Thus, 4G is failing to keep up with the rising demands of modern wireless communications. The proposed fifth generation (5G) standards aim to solve these problems. 5G promises high data rate from 2 Gbps to 20 Gbps, spectrum efficiency of 9 bits/s/Hz, a connection density of 1 million/km^2, and mobility of up to 500 km/h [2]. 5G communication will utilize sub-6 GHz and millimeter-wave (mmWave) frequency bands [3]. The frequency range 24.25 – 29.5 GHz is accepted globally for future 5G mmWave communication [4].

Wireless communication that uses higher frequencies suffers from high path losses [5]. This demands for an antenna with a higher gain and good radiation pattern. Furthermore, there is demand for small and lightweight antennas. A Vivaldi antenna meets these requirements.

A Vivaldi antenna is an exponentially Tapered Slot Antenna (TSA) with a tapered slot etching placed on a dielectric substrate [5]. A Vivaldi antenna offers wide bandwidth, high gain, end-fire radiation patterns, geometric simplicity, and ease of fabrication [5], [6]. First introduced by P. J. Gibson in 1979 [7], there are three categories of Vivaldi antennas: Coplanar, Antipodal, and Balanced Antipodal. Antipodal Vivaldi Antenna (AVA) has one radiator layer placed on top of a substrate, and another tapered layer placed on the bottom of the substrate. A connector feed is connected to one side of the dielectric sheet touching both top and bottom radiator layers. AVA is commonly preferred because of this feeding simplicity [8].

Vivaldi antennas suffer from limitations in gain and directivity [9]. Different modifications have been proposed. Varying parameters like exponential rate, length, dielectric thickness and dielectric material affects beamwidth [10]. Varying substrate characteristics also affects directivity [11]. Addition of structures such as 'lens' [12], 'directors' [12] [6], and grating strips [6] along the end-fire region improves directivity. These modifications guide the signal energy along its direction. Addition of corrugations as resistive loads along slot edges reduces sidelobes and improves gain [6]. Addition of metamaterials improve gain and bandwidth [13] [14]. Metamaterials affect wave propagation properties.

Single element antennas usually have poor gain and directivity in higher frequencies [5]. Array antennas are proposed to improve these radiation characteristics, although arrays are regarded as costly, complex, and bulky [6]. [15] presents an 8-element AVA array for 5G mmWave communication application. A 1-to-8 power divider network and a ground plane were used to connect a feed in the top and bottom layers respectively. Modifications with addition of notch structures in the ground region, reduced coupling between elements. The work in [15] is modified by [16]. [16] considers addition of six meta-surface (MS) unit cells in the aperture regions. One MS consists of two-stub-loaded split-ring resonators. Addition of MS cells corrected phase distribution in the aperture region. In [1], a four-element AVA array is presented. Corporate feeding is used which is shown to improve input impedance. Corrugations are added in the radiating slots and ground plane. In this work, corrugations improve element isolation thus reducing mutual coupling. Front-to-back ratio is also affected.

This paper presents a four-element AVA antenna array for 5G mmWave communication applications. Cuts will be included in the radiating slots to modify current distribution. In the real world, radiation from one element is received by a neighboring element, which can be re-radiated to a different

direction – a situation called mutual coupling [1]. Notch structures will be included along the middle area of the ground plane. This will improve element isolation, reducing mutual coupling.

This paper is organized as follows: Section II details the proposed array design, Section III presents results of the designed antenna, and Section IV states the conclusion.

II. ANTENNA DESIGN

Design and simulations were implemented using High Frequency Structure Simulator (HFSS). Initially a single element AVA was designed. Then an array comprising four of these AVA elements and a power divider was designed. Modifications in form of cuts in radiating slots and feeding section of the ground structure were added. The overall size of the antenna is $28 \times 32 \times 1.6$ mm^3. These are discussed in detail below.

A. Single Element AVA

Two radiating slots made of copper (0.035 mm thick) were designed with exponential tapering edges defined by [14],

$$x = \begin{cases} w_f - 0.5w_f e^{\alpha y} & top\ layer \\ -w_f + 0.5w_f e^{\alpha y} & bottom\ layer \end{cases} \quad (1)$$

Where x is the exponential curve, w_f is the width of the feed-line, α is the exponential transition rate given by the equation,

$$\alpha = \frac{1}{TL} \ln \left(\frac{w_f + 0.5w_a}{0.5w_f} \right) \quad (2)$$

Where TL is length of the tapered end, w_a is aperture size.

These slots were placed one on top of a dielectric substrate and another on the bottom of this substrate, facing in opposite directions with respect to the exponential curve. Substrate material used was FR-4 epoxy with relative permittivity (ε_r) 4.4; loss tangent (tan δ) 0.02; and thickness 1.6 mm. This design is shown in Fig. 1.
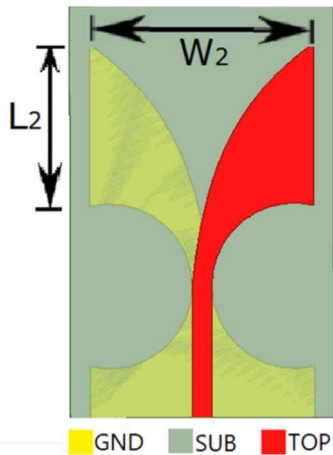
Fig. 1. Single Element AVA (GND = ground element, SUB = substrate, and TOP = top element).

B. Antenna Array Design

In order to have better radiation properties, an antenna array of four AVA elements was designed. To reduce mutual coupling between neighboring elements, notch structures were added in the middle region of the ground radiating plane. A power divider/combiner was also designed for proper feeding arrangement. This design uses corporate feeding where each element is excited equally. A natural transition is used with an SMA connector of 50 Ω impedance. The designed AVA array is shown in Fig. 2.
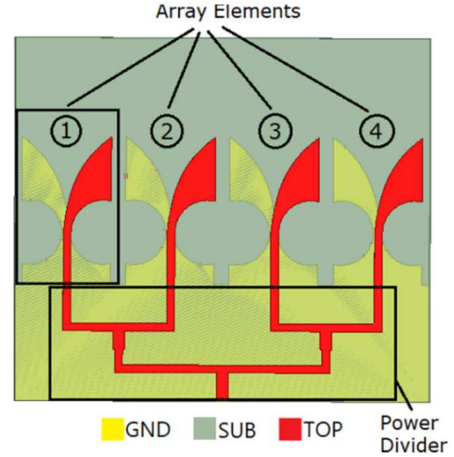
Fig. 2. Four-Element AVA array with a 3 dB Power Divider.
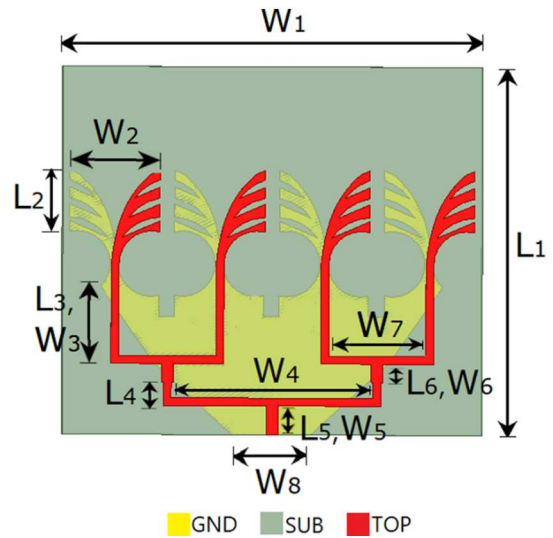
Fig. 3. AVA array with geometrical modifications.

TABLE I.   ANTENNA GEOMETRIC PARAMETERS (mm)

L₁	L₂	L₃	L₄	L₅	L₆	W₈
28	4.67	5.8	1.8	2.2	1.4	6
W₁	W₂	W₃	W₄	W₅	W₆	W₇
32	6.8	0.6	15.4	0.9	0.75	7.4

C. Antenna Array Modifications

The designed array did not show satisfactory results in S11 and gain against frequency plots. In order to improve radiation characteristics, two types of modifications were done. Firstly, cuts were added to both top and bottom radiating slots. Three cuts were added to each radiating slot along the taper curve, making a finger-like shape. These cuts changed distribution of current along the radiating slots. Secondly, cuts were added on the feeding section of the ground structure. Cuts in the ground structure improved impedance matching and gain. The final designed antenna is shown in Fig. 3. Geometric parameters of the design are shown in Table 1.

III. RESULTS AND DISCUSSIONS

This section discusses simulated results of the proposed antenna. These are discussed in terms of current distribution, reflection coefficient, VSWR, radiation patterns and gain vs frequency plot.

A. Surface Current Distribution of the array antenna:

Fig. 4 shows simulated surface current distributions at 26 and 29 GHz for AVA array and modified AVA array. It is observed that in the basic AVA array current is distributed along the edges of the conducting planes. After addition of slot cuts, there is redistribution of current flow at the same frequencies. The finger-shaped orientation causes the conductors to behave as RLC resonators. Further comparing the basic array and modified array, it is shown there is phase correction. This is due to the modifications included in the ground plane.
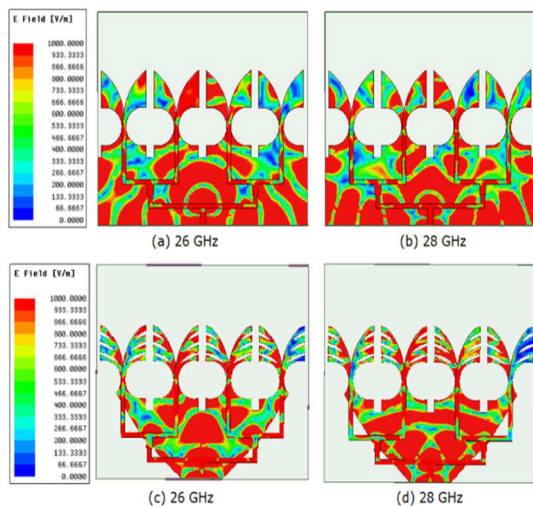
Fig. 4. Current distributions of AVA array at – (a) 26 GHz, (b) 28 GHz; and modified AVA array at – (c) 26 GHz, (d) 28 GHz.

B. Reflection Coefficient (S11) analysis plot of the array antenna:

S11 results are shown in Fig. 5. The basic AVA array has S11 of less than –32 dB at 26.25 GHz. Ground plane modifications improve impedance matching and introduce resonances in the region between 24.5 GHz to 26.5 GHz and

27 GHz to 28.5 GHz. After modifications, the proposed design has S11 of less than –10 dB in frequencies between 22.8 – 29.1 GHz, which covers almost all of the targeted band of 24.25 – 29.5 GHz mm wave band.

C. VSWR plot:

Fig. 6 shows VSWR plot of the array antenna. Impedance matching due to ground plane modifications improved VSWR well below 2. Without modifications, there is mismatch in the higher frequencies (27 – 28.5 GHz). VSWR is greatly improved in the lower frequencies (24 GHz – 26 GHz).
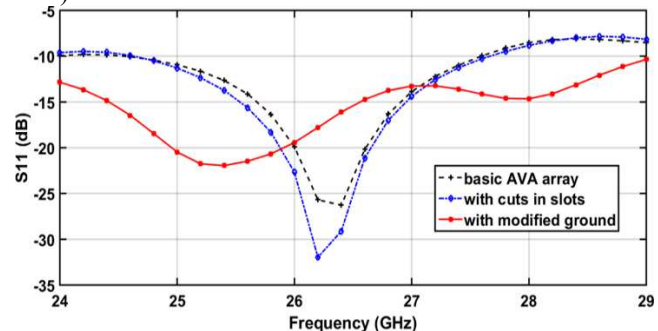
Fig. 5. S11 vs frequency plot of the array antenna.
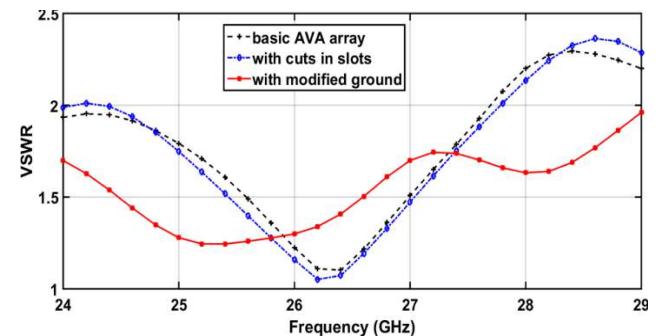
Fig. 6. VSWR plot of the array antenna.

D. Radiation Patterns plot of the antenna:

Fig. 7 shows simulated radiation patterns for (i) basic array antenna, (ii) array with slot cuts and (iii) array with modified ground at 26 GHz and 29 GHz. Generally, planar antennas have weakness of having wider radiations in the horizontal plane [5]. Horizontal plane plots show that insertion in the ground plane cuts reduce side lobes of the antenna array. Furthermore, directivity is further improved at 26 GHz. Similarly, directed beams with less side lobes are achieved in the elevation planes after adding modifications.

E. Gain vs Frequency plot of the antenna:

Fig. 8 shows gain vs frequency plot of the antenna. Basic AVA array has negative gain in frequencies between 24 GHz to 27 GHz. This must be due to improper impedance match and high number of side lobes achieved during radiation. After addition of required modifications which improve impedance, correct phase errors and reduce side lobes, there are directed beams and improvement in gain performance as

shown. Maximum gain achieved by the array antenna is 8.1 dB at 26.5 GHz.

(a)   (b)

(c)   (d)
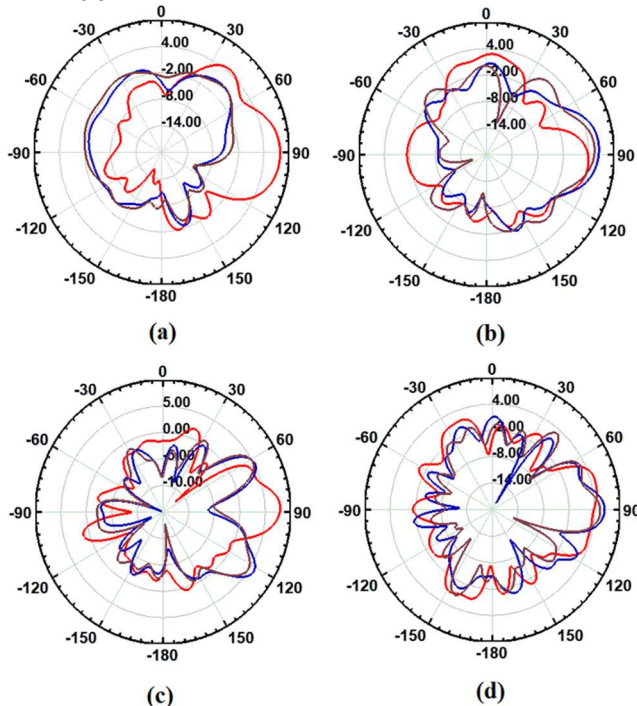
Fig. 7. Radiation patterns for AVA array (grey), AVA array with slots (blue), and AVA array with slots and modified ground plane (red): – Elevation (Vertical) plane at: (a) 26, (b) 29 GHz, and – Azimuthal (Horizontal) plane at: (c) 26, (d) 29 GHz.
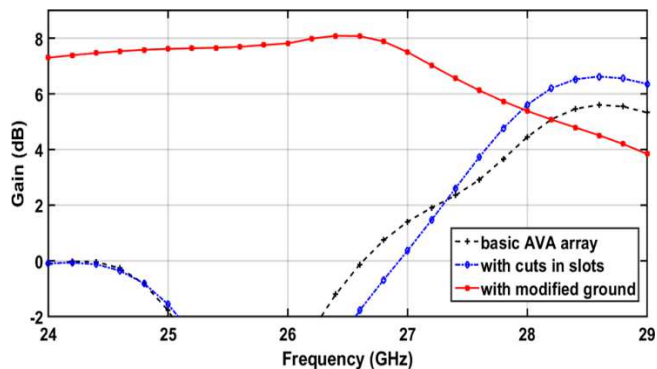
Fig. 8. Gain vs frequency plot of the array antenna.

IV. CONCLUSSION

In this paper, an antipodal Vivaldi antenna array has been proposed. This design was modified with addition of slot cuts in the radiating slots and cuts in the ground plane. Slot cuts improve current distribution. Ground plane modifications improve impedance matching, correct phase errors, and reduce side lobes. This leads to an improved maximum gain of 8.1 dB at 26.5 GHz. The antenna operates in frequency range 22.8 – 29.1 GHz (S11 < –10 dB) which covers the targeted 5G mmWave frequency range *n257* & *n258* for future

mobile communication. Furthermore, the designed antenna is small in size and uses low-cost commercial materials for fabrication.

REFERENCES

[1] A. S. Dixit, S. Kumar, S. Urooj, and A. Malibari, "A Highly Compact Antipodal Vivaldi Antenna Array for 5G Millimeter Wave Applications." Sensors, vol. 21, no. 7, pp.: 2360, 2021.

[2] ITU-R. Minimum Requirements Related to Technical Performance for IMT-2020 Radio Interface(s); Report ITU-R M.2410-0; ITU-R: Geneva, Switzerland, 2017; pp. 1–11.

[3] Https://www.gsma.com/spectrum/5g-spectrum-guide/

[4] O. O. Erunkulu, A. M. Zungeru, C. K. Lebekwe, M. Mosalaosi and J. M. Chuma, "5G Mobile Communication Applications: A Survey and Comparison of Use Cases," in IEEE Access, vol. 9, pp. 97251-97295, 2021, doi: 10.1109/ACCESS.2021.3093213.

[5] C. A. Balanis, Antenna Theory, Analysis and Design. 4th ed., John Wiley and Sons, NJ, USA, 2016.

[6] X. X. Li, B. J. Lu, L. Sang, Y. M. Zhang, and G. Q. Lv, "Radiation enhanced Vivaldi antenna with shaped dielectric cover." Microwave and Optical Technology Letters, vol. 59, no. 8, pp. 1975-1983, 2017.

[7] P. J. Gibson, "The Vivaldi aerial." 9th European Microwave Conference, UK, pp. 101-105, 1979.

[8] E. Gazit, "Improved design of the Vivaldi antenna." IEE Proceedings H (Microwaves, Antennas and Propagation), vol. 135, no. 2, pp. 89-92. IET Digital Library, 1988.

[9] N. Nurhayati, A. M. De Oliveira, J. F. Justo, E. Setijadi, B. E. Sukoco, and E. Endryansyah, "Palm tree coplanar Vivaldi antenna for near field radar application." Microwave and Optical Technology Letters, vol. 62, no. 2, pp. 964-974, 2020.

[10] N. Hamzah, and K.A. Othman, "Designing Vivaldi antenna with various sizes using CST software." Proceedings of the World Congress on Engineering, vol. 2, pp. 6-8. July, 2011.

[11] Y. W. Wang, G. M. Wang, and B. F. Zong, "Directivity improvement of Vivaldi antenna using double-slot structure." IEEE Antennas and Wireless Propagation Letters, vol. 12, pp. 1380-1383, 2013.

[12] X. Zhang, Y. Chen, M. Tian, J. Liu, and H. Liu, "A compact wide-band antipodal Vivaldi antenna design." International Journal of RF and Microwave Computer-Aided Engineering, vol. 29, no. 4, e21598, 2019.

[13] M. Sun, Z. N. Chen, and X. Qing, "Gain enhancement of 60-GHz antipodal tapered slot antenna using zero-index metamaterial." IEEE Transactions on Antennas and Propagation, vol. 61, no. 4, pp. 1741-1746, 2012.

[14] A. S. Dixit, and S. Kumar, "The enhanced gain and cost-effective antipodal Vivaldi antenna for 5G communication applications." Microwave and Optical Technology Letters, vol. 62 no. 6, pp. 2365-2374, 2020.

[15] S. Zhu, H. Liu, Z. Chen, and P. Wen, "A compact gain-enhanced Vivaldi antenna array with suppressed mutual coupling for 5G mmWave application." IEEE Antennas and Wireless Propagation Letters, vol. 17, no. 5, pp.: 776-779. 2018.

[16] S. Zhu, H. Liu, and P. Wen, "A new method for achieving miniaturization and gain enhancement of Vivaldi antenna array based on anisotropic metasurface." IEEE Transactions on Antennas and Propagation, vol. 67, no. 3, pp.: 1952-1956. 2019.

A Modified Antipodal Vivaldi Antenna with Slot and Feed-line Cuts for Ultra-wideband Applications

Innocent Kadaleka Phiri
Department of Electronics and
Comunication Engineering,
Gauhati University,Assam, India
innocentkphiri@gmail.com

Kumaresh Sarmah
Department of Electronics and
Comunication Technology,
Gauhati University,Assam, India
kumaresh@gauhati.ac.in

Abstract—A geometrically modified Antipodal Vivaldi Antenna (AVA) for applicable in Ultra-wideband (UWB) frequency is proposed in this paper. A conventional AVA is designed on a low-cost dielectric FR-4 substrate of size 41 × 35 × 1.6 mm³. Cuts are added on the radiating slots and feedline to improve bandwidth and gain. Design and optimization are done using a 3D electromagnetic simulator, High Frequency Structure Simulator (HFSS). The designed antenna operates in frequencies between 3.3 – 13.4 GHz (S11 < –10 dB) making it suitable for all Ultra-wideband applications. Maximum gain is 9 dB at 10.5 GHz.

Keywords—Antipodal Vivaldi Antenna (AVA), Ultra-wideband (UWB), Slot cuts, Feed-line cuts, wideband

I. INTRODUCTION

The advancements and developments in wireless communications have led to many applications utilizing the ultra-wideband (UWB). Utilizing frequencies between 3.1 to 10.6 GHz, UWB offers many applications including radar, biomedical imaging, remote sensing, satellite communications, RF jamming, radio astronomy, and radio telescope [1]. Due to these wide applications, there have been innovations on suitable antennas to realize the applications. Horn antennas are one type suitable for such applications [2]. With the high demand for small and lightweight designs, a Vivaldi antenna was designed [3].

A Vivaldi antenna was initially introduced and proposed by P. J. Gibson in the year 1979, with an exponential tapered slot placed on a dielectric substrate material [3]. This was later modified by E. Gazit in 1988 who suggested an antipodal Vivaldi antenna (AVA) [4]. AVA has one tapered radiator layer on top of the substrate and another tapered layer on the bottom of the substrate. A Vivaldi antenna has wide bandwidth, good radiation, good directivity, low side lobes, geometric simplicity, and is easy to fabricate [5]. These characteristics make it suitable for UWB applications.

In practice, the Vivaldi antenna has limitations in radiation characteristics, gain and directivity [7]. Many modification techniques have been presented in literature. [8] reports that varying the length of the radiator, shape, dielectric thickness and dielectric constant affects the beamwidth of operation of the antenna. While [9] reports that varying substrate permittivity and thickness also affects the antenna directivity.

Other authors have added or removed structures on the antenna surface. According to [10], adding corrugations along the slot edges improves gain and reduces sidelobes. This is because these corrugations adjust current distribution by working as resistive loads [5]. Other structures added in the tapered slots such as: 'lens' [1], 'directors' [1] [5], grating strips [10], and metamaterials [11]. According to [10], grating

strips added along the direction of radiation improve directivity. [5] adds that directors and grating strips placed in the flare guide energy along the end-fire direction. Another technique involves use of antenna array, but sometimes regarded as costly, complex, and bulky [5].

This paper presents a modified AVA for Ultra-wideband applications. This design will be modified with addition of cuts in the radiators and feed-line section. The paper is organized in this manner: Section II describes the proposed design, Section III discusses simulated results of the antenna, and in Section IV conclude the results.

II. ANTENNA DESIGN

The design was done in High Frequency Structure Simulator (HFSS) software. The proposed antenna was designed on a cost-efficient FR-4 epoxy dielectric substrate with relative permittivity (ε_r) of 4.4 and loss tangent of the dielectric substrate (tan δ) of 0.02; and thickness 1.6 mm. The overall size of this proposed antenna is 41 × 35 × 1.6 mm³ (L_s × W_s × H_s). Design of the exponential slots, feeding consideration and antenna modifications are discussed in the subsections that follow.

A. Exponential Slots Design

Two conducting slots made of copper with thickness 0.035 mm, were designed with an exponential edge. These slots were spread in opposite directions to make a tapered edge, and then one was placed on top and the other under the substrate. The tapered edges are defined by [14],

$$x = \begin{cases} w_f - 0.5w_f e^{\alpha y} & top\ layer \\ -w_f + 0.5w_f e^{\alpha y} & bottom\ layer \end{cases} \quad (1)$$

Where x is the exponential curve, w_f represents the width of the feed-line, α is the exponential tapering rate given by the equation,

$$\alpha = \frac{1}{TL} \ln\left(\frac{w_f + 0.5w_a}{0.5w_f}\right) \quad (2)$$

Where TL is the length of the tapered end, w_a is the aperture size.

According to [2], choice of aperture width, w_a, of a Vivaldi antenna affects lower operating frequency while opening width, w_f, affects highest operating frequency. Furthermore, increasing rate of exponent, α, increases aperture width, w_a.

B. Feeding Design

Feeding is through natural transition from a microstrip line. This line is connected to an SMA connector with 50 Ω
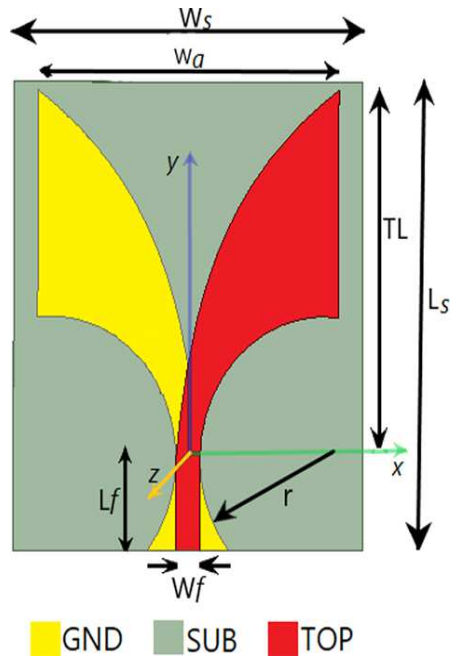
Fig. 1. Design geometry of the basic AVA. (GND = ground element, SUB = substrate, and TOP = top element).

impedance. The antipodal design in AVA solves coplanar feeding problem of Coplanar Vivaldi Antennas (CVA). Fig. 1 shows the basic AVA, while Table 1 shows geometrical parameter with given dimensions of the antenna.

TABLE I.   ANTENNA GEOMETRIC PARAMETERS

Parameter	Description	Value (mm)
L_s	Substrate length	41
W_s	Substrate width	35
H_s	Substrate height	1.6
TL	Taper length	33
W_a	Opening width	30.2
R	Circle radius	12.5
L_f	Feed-line length	8
W_f	Feed-line width	2.4
A	Cut gap width	1.5
B	Cut axis length	14.3
C	Diagonal distance	3.8
D	Slot cut width	0.5
E	Slot cut length	0.75
α	Exponential rate	0.083 (no units)

C. Modifications Added to the Basic Antenna Design

Modifications were added to improve bandwidth and gain of the antenna. Cut slots were added to both top and ground radiating slots resulting in finger-like shaped radiators. Six cuts were added to each radiator, with adjacent slot cuts separated 3.8 mm with respect to the exponential curve. Without cuts, current was distributed along the edges of the radiators. when cuts are added, they change distribution of these currents to also go along the finger shapes.
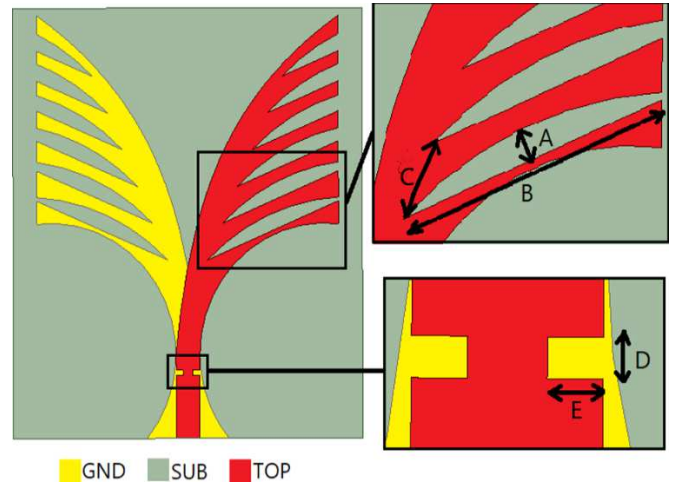
Fig. 2. AVA with geometrical modifications at top amd bottom side of the antenna.

In addition, a pair of cuts was added on the feed-line section. Size and position of these feed-line cuts were varied. This modification compensates for the small size of the antenna without giving losses to its electromagnetic properties. Feed-line cuts improved directivity and radiation patterns. Fig. 2 shows the modified AVA.

III. RESULTS AND DISCUSSIONS

This proposed antenna is simulated in HFSS and in this section discusses the simulated results.

A. Reflection Coefficient (S11) of the Antenna

Fig. 3 shows simulated S11 results of the (i) basic AVA antenna, (ii) AVA with slot cuts, and (iii) AVA with slot cuts and feed-line cuts. From the plot, the final AVA has impedance bandwidth on frequencies between 3.3 – 13.4 GHz (S11 < –10 dB). This implies that this geometrical modification in the antenna design operates in the targeted UWB band. Addition of slot cuts induces multiple resonances specifically at low frequencies. S11 improves in frequencies between 2.5 to 5 GHz, 7 to 8 GHz and 11 to 13.5 GHz, extending the bandwidth. A radiating slot without cuts is characterized as a resistor, whereas one with the finger-like design works as an RLC resonator [14].
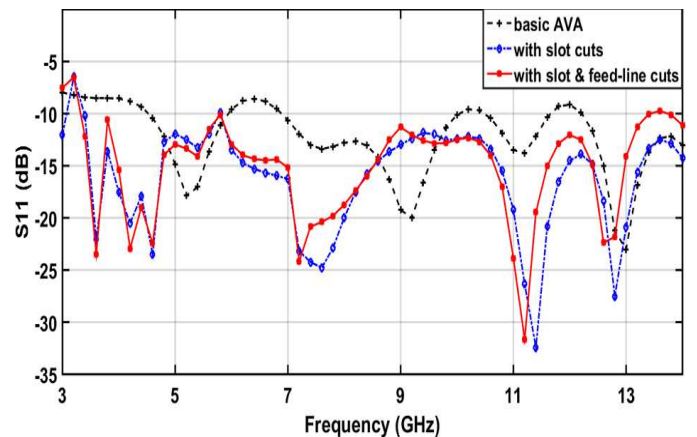
Fig. 3. S11 vs frequency plot of the antenna showing the UWB frequency band from 3 to 13 GHz.

Fig. 6. VSWR plot of the antenna shows UWB frequency operation.
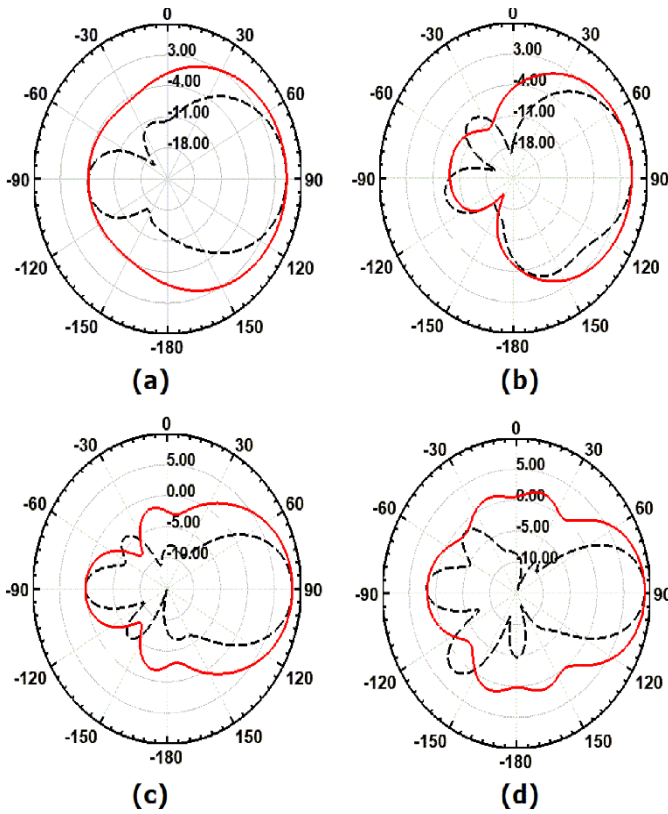
Fig. 4. Radiation patterns of the antenna: Elevation (red) and Azimuth (dotted black) planes at (a) 5.8, (b) 7, (c) 9.6 and (d) 10.6 GHz.

B. Radiation Pattern Results of the AVA

Fig. 4 represents simulated far field radiation patterns of the final proposed modified antenna. The simulation shows radiation patterns in both Elevation and Azimuth planes at frequencies 5.8 GHz ,7 GHz, 9.6 GHz and 10.6 GHz. The radiation pattern shows a directional radiation beam along the desired direction for the entered UWB frequency band of operation. It has been further observed that as the simulation frequency of operation increases, the beamwidth of the antenna radiation decreases. It indicated more directive beam of the modified Vivaldi antenna at higher frequency operation. More side lobes are observed at higher frequencies.
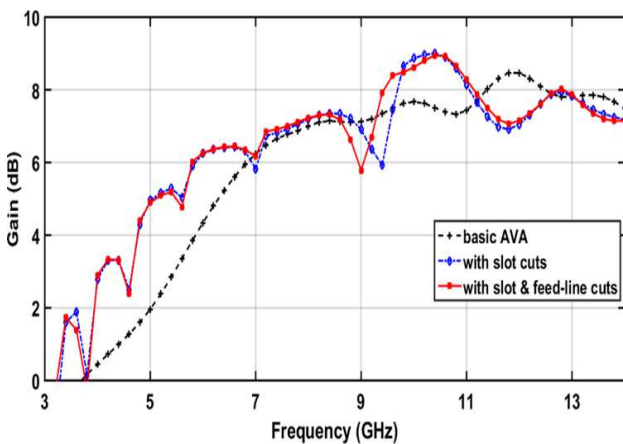
Fig. 5. Gain vs frequency plot of the Vivaldi antenna.

C. Gain vs Frequency Plot of the Antenna

Fig. 5 shows simulated gain against frequency results for (i) basic AVA antenna, (ii) AVA with slot cuts, and (iii) AVA with slot cuts and feed-line cuts. Basic AVA has low gain. After addition of slots, antenna gain increases. Antenna achieves a maximum 9 dB gain at 10.5 GHz by the modified AVA. At lower operating frequencies there is low gain, but as frequency increases, antenna gain also increases, only decreasing after 11 GHz. This is due to phase errors at the antenna end-flare [1] [5]. This is because of the losses attributed due to increase in the effective current path along the slits of the radiating patch of the antenna.

D. Voltage Standing Wave Ratio (VSWR) of the Antenna

A properly matched antenna usually has VSWR value equal or less than 2. Fig. 6 compares the simulated VSWR results for the proposed three designs. The usual AVA curve has more regions with VSWR greater than 2, which shows mismatch. Addition of slot cuts on this basic AVA makes the VSWR to drop below the required mark of 2 throughout the target frequencies. The final modified AVA plot shows it is well matched throughout the targeted UWB frequencies. This means that the antenna is well matched and reflects less power in these frequencies.

E. Comparison with Other Previous Antenna Designs

A comparison is done between this proposed model and some previous antenna reported in the reference designs and is concluded in a separate table as shown in Table 2. The Table 2. Is included in the last part of the paper.

IV. CONCLUSION

This research paper proposes a structurally modified Antipodal Vivaldi Antenna with introducing cut slots and feed-line cuts in the radiating patch of the antenna. These modifications improved bandwidth, gain, directivity and radiation patterns. The operational bandwidth is between 3.3 – 13.4 GHz (S11 < –10 dB) covering the Ultra-wideband frequency range. The antenna achieves a maximum 9 dB gain at 10.5 GHz.

The proposed antenna is compact in size and suitable for fabrication on cost efficient FR4-epoxy substrate which can be used for entire band of Ultra-wideband frequency.

REFERENCES

[1] X. Zhang, Y. Chen, M. Tian, J. Liu, and H. Liu, "A compact wide - band antipodal Vivaldi antenna design." International Journal of RF and Microwave Computer - Aided Engineering, vol. 29, no. 4, e21598, 2019.

[2] C. A. Balanis, Antenna Theory, Analysis and Design. 4th ed., John Wiley and Sons, NJ, USA, 2016.

[3] P. J. Gibson, "The Vivaldi aerial." 9th European Microwave Conference, UK, pp. 101-105, 1979.

[4] E. Gazit, "Improved design of the Vivaldi antenna." IEE Proceedings H (Microwaves, Antennas and Propagation), vol. 135, no. 2, pp. 89-92. IET Digital Library, 1988.

[5] X. X. Li, B. J. Lu, L. Sang, Y. M. Zhang, and G. Q. Lv, "Radiation enhanced Vivaldi antenna with shaped dielectric cover." Microwave and Optical Technology Letters, vol 59, no. 8, pp. 1975-1983, 2017.

[6] A. R. Bayat, and R. Mirzakhani, "A parametric study and design of the balanced antipodal Vivaldi antenna (BAVA)." in PIERS Proceedings. 19 August, 2012.

[7] N. Nurhayati, A. M. De Oliveira, J. F. Justo, E. Setijadi, B. E. Sukoco, and E. Endryansyah, "Palm tree coplanar Vivaldi antenna for near field radar application." Microwave and Optical Technology Letters, vol. 62, no. 2, pp. 964-974, 2020.

[8] N. Hamzah, and K. A. Othman, "Designing Vivaldi antenna with various sizes using CST software." Proceedings of the World Congress on Engineering, vol. 2, pp. 6-8. July, 2011.

[9] Y. W. Wang, G. M. Wang, and B. F. Zong, "Directivity improvement of Vivaldi antenna using double-slot structure." IEEE Antennas and Wireless Propagation Letters, vol. 12, pp. 1380-1383, 2013.

[10] G. K. Pandey, and M. K. Meshram, "A printed high gain UWB Vivaldi antenna design using tapered corrugation and grating elements." International Journal of RF and Microwave Computer - Aided Engineering, vol. 25, no. 7, pp. 610-618, 2015.

[11] M. Sun, Z. N. Chen, and X. Qing, "Gain enhancement of 60-GHz antipodal tapered slot antenna using zero-index metamaterial." IEEE Transactions on Antennas and Propagation, vol. 61, no. 4, pp. 1741-1746, 2012.

[12] G. K. Pandey, H. S. Singh, P. K. Bharti, A. Pandey, and M. K. Meshram, "High gain Vivaldi antenna for radar and microwave imaging applications." International Journal of Signal Processing Systems, vol 3, no. 1, pp. 35-39, 2015.

[13] A. S. Dixit, and S. Kumar, "The enhanced gain and cost - effective antipodal Vivaldi antenna for 5G communication applications." Microwave and Optical Technology Letters, vol. 62 no. 6, pp. 2365-2374, 2020.

[14] J. Bai, S. Shi, and D. W. Prather, "Modified compact antipodal Vivaldi antenna for 4–50-GHz UWB application." IEEE Transactions on Microwave Theory and Techniques, vol 59, no. 4, pp. 1051-1057, 2011.

[15] M. Y. Perdana, T. Hariyadi, and Y. Wahyu, "Design of Vivaldi microstrip antenna for ultra-wideband radar applications." IOP Conference Series: Materials Science and Engineering, vol. 180, no. 1, pp. 012058, IOP Publishing, 2017.

[16] M. Moosazadeh, and S. Kharkovsky, "Design of ultra-wideband antipodal Vivaldi antenna for microwave imaging applications." 2015 IEEE International Conference on Ubiquitous Wireless Broadband (ICUWB), pp. 1-4, IEEE, October, 2015.

TABLE II. A COMPARISON TABLE OF THE PROPOSED AVA WITH REFERRED DESIGN

Ref.	Antenna Type & DesignTechnique	Size (mm^3)	Substrate (ε_r)	Freq. band (GHz)	Max. Gain
[1]	AVA, director and lens	34 × 16 × 0.8	FR4-epoxy (4.6)	3.01 – 10.6	6.3 dB
[12]	Regular VA, gratings and corrugations	45 × 40 × 0.8	FR4-epoxy (4.4)	2.9 – 11	8.2 dB
[15]	Regular VA, parallel slot cuts	50 × 40 × 1.6	FR4-epoxy (4.3)	3.1 – 10.7	8.02 dBi
This work	**AVA, slot and feed-line cuts**	**41 × 35 × 1.6**	**FR4-epoxy (4.4)**	**3.3 – 13.4**	**9 dB**

Chapter 5

Semiconductor Quantum Dot Solar Cells: Construction, Working Principle, and Current Development

Hirendra Das ✉, Pranayee Datta

Book Editor(s):Nayan Kumar, Prabhansu

Summary

With the increasing global population and technological and industrial revolution of the 21 st century, the demand of energy is also increasing rapidly around the world. Over the past few decades, quantum dot sensitized solar cells (QDSSCs) have attracted significant interests due to their interesting electrical and optical properties. With tuneable band-gap and particle size, quantum dots can absorb a wide range of solar spectrum with high efficiency. The multiple exciton generation (MEG) phenomenon could overcome the theoretical single junction power conversion efficiency limitations. In a recent report, QDSSCs showed power conversion efficiencies up to 16.6%, very close to the dyesensitized solar cells. In this chapter, we discuss the historical background, working principle, and other design aspects of QDSSCs on the basis of our practical works. We will also discuss the current research and development in this field and what the future holds for QDSSCs.

References ⌄

Alagarsamy P. , Ramaraj R. , Rational Design of Solar Cells for Efficient Solar Energy Conversion (first ed.) , *Wiley* , ISBN: 978-1-119-43740-6, 2018 .

Ichikawa Y. , Yoshida T. , Hama T. , Sakai H. , Harashima K. , Production technology for amorphous silicon-based exible solar cells , *Sol. Energy Mater. Sol. Cells* , **66** , 107 – 115 , 2001 .

English language teaching, learning and assessment in India:
Policies and practices in the school education system

Simon Borg, Amol Padwad and Pranjana Kalita Nath

English language teaching, learning and assessment in India: Policies and practices in the school education system

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Acknowledgements

We gratefully acknowledge the input provided for this report by the teachers and teacher educators who shared their experiences of English language teaching and learning in India.

Contents

Introduction to the series

Across South Asia, English is widely seen as the language of social mobility, educational opportunity, employability, global business and dialogue. Many consider English language skills to be an essential component of economic development and growth – both on an individual and national level. However, the inclusion of English within language-in-education policies that must simultaneously promote other national languages, along with its history as a colonial and/or elite language in most countries in this region, means that it does not always sit easily within education systems. The place of English within school systems in South Asia has fluctuated over time and a number of challenges remain around ensuring equitable, high-quality provision of English language teaching and learning for all who want or need it.

This report is one of a series of five focusing on the policy and practices relating to English language education in Bangladesh, India, Nepal, Pakistan and Sri Lanka. It aims to provide a contemporary snapshot of the role that English currently plays within the lives of school children and the wider community. It explores the current scenario, considering both the private and government school sectors, including reflections on the impact of the Covid-19 crisis. It also looks to the future: how might some of the current challenges be addressed, and what opportunities exist to support the development of this aspect of the school education system?

Across the series, the author teams collaborated in defining the overall focus and structure, and peer-reviewed each other's work to provide feedback and ensure coherence across the reports. The authors have focused primarily on a review of policy documentation, reports and data provided by relevant government departments, academics and international agencies. This is supported by input from a small number of important stakeholders such as teachers, curriculum and textbook writers, and policy officers. Their input is often included verbatim to provide further contextualised insight into the realities of the classroom and wider education system.

Providing a detailed overview of even a single subject like English within any school education system is a significant task, particularly in large, complex and multilingual countries. Coupled with the historical, political and cultural factors that are unique to English in South Asia, we are conscious that these reports have their limitations and can serve mainly as an entry point to this vast and complicated topic. Nevertheless, we hope that readers will find them informative and useful for critical discussion, research and development – particularly those who are involved in English language education implementation in this region.

To access the full series of reports, please visit our TeachingEnglish website: www.teachingenglish.org.uk/article/english-language-teaching-learning-assessment-south-asia

Amy Lightfoot
Director Insight and Innovation
English Programmes
British Council

Abbreviations

ASER	Annual Status of Education Report
BEd	Bachelor of Education
CABE	Central Advisory Board of Education
CBSE	Central Board of Secondary Education
CCE	Continuous and Comprehensive Evaluation
CEFR	Common European Framework of Reference for Languages
CISCE	Council for the Indian School Certificate Examination
CPD	Continuing Professional Development
CSR	Corporate Social Responsibility
CTE	College of Teacher Education
CTET	Central Teacher Eligibility Test
DElEd	Diploma in Elementary Education
DIET	District Institute for Education and Training
DIKSHA	Digital Infrastructure for Knowledge Sharing
EFLU	English and Foreign Languages University
ELTI	English Language Training Institutes
EMI	English Medium Instruction
ETA	English Teacher Association
IASE	Institutes of Advanced Studies in Education
ICT	Information and Communications Technology
ITEP	Integrated Teacher Education Programme
KVS	Kendriya Vidyalaya Sangathan
MHRD	Ministry of Human Resource Development
MITRA	Maharashtra In-service Teachers Resource App
NCERT	National Council of Educational Research and Training
NCF	National Curriculum Framework
NCFTE	National Curriculum Framework for Teacher Education
NCTE	National Council for Teacher Education
NEP/NPE	National Education Policy/National Policy on Education
NGO	Non-Governmental Organisation
NIEPA	National Institute of Educational Planning and Administration
NIOS	National Institute of Open Schooling
NPST	National Professional Standards for Teachers
OER	Open Education Resources
PET	Pre-entry Test
PISA	Programme for International Student Assessment
RIE	Regional Institute of English
RMSA	Rashtriya Madhyamik Shiksha Abhiyan (National Secondary Education Mission)
SCERT	State Council of Educational Research and Training
SCF	State Curriculum Framework
SEBA	Board of Secondary Education Assam
SSA	Samagra Shiksha Abhiyan (Integrated Education Mission)
TET	Teacher Eligibility Test
TLM	Teaching and Learning Material
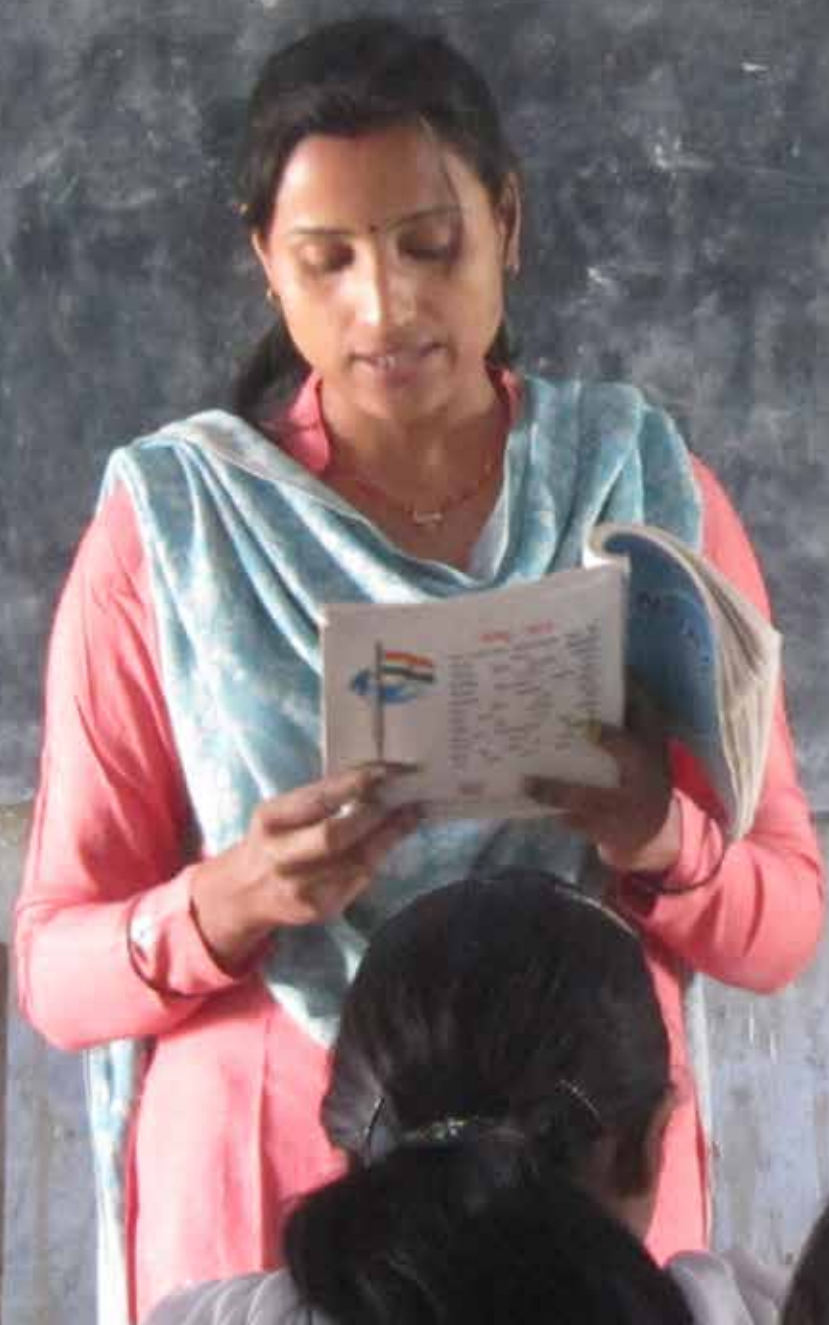
Executive summary

Education in India is immensely complex and varied. In addition to the sheer scale of schooling in the country – 1.5 million schools, 260 million learners and 9.7 million teachers – national educational policies operate alongside those defined and implemented locally in 28 states and eight union territories. There are also over 400,000 private schools – often loosely regulated and with more autonomy than government schools – which account for a substantial proportion of school-age students in the country. India is also richly multilingual, with hundreds of languages in use and a national policy that emphasises the study of at least three languages at school. It is within this complex educational landscape that the teaching and learning of English unfolds.

English in India is, in fact, a conundrum because, despite the value attached to it (children learn it for seven to ten years at school) and the benefits (socially, for employment, leisure and study) that accrue from its mastery, the over-riding sense that persists is that the quality of English teaching and learning across primary and early secondary education is modest, a factor that feeds into low English proficiency at subsequent stages of education, including among university students and in the population more generally.

This report provides insight into this problem by reviewing the current status of English in the Indian education system. It is informed by a desk-based review of policy documents, educational reports, academic papers and information available online, such as official government statistics. This desk work is supplemented by a small number of interviews with practitioners – teachers and teacher educators – with first-hand experience of English education in the country. Overall, the goals of the analysis presented here are to describe what is known about various aspects of English education in India and to make recommendations for issues that can be a productive focus of efforts – by national and state governments and the many educational partners they work with – to improve English teaching and learning.

Following a brief analysis of the Indian education system and the role of languages generally and English specifically in the country, the report focuses on the practice of English language teaching and teacher education, including the continuing professional development (CPD) of teachers of English. The following key points emerge from the analysis:

1. National- and state-level educational policies operate simultaneously but may not always be wholly consistent given the autonomy that states have. Policies provide a good basis for reform but are often not supported by mechanisms that lead to effective implementation.

2. Across school education, governments have invested in numerous large-scale initiatives that aim to support teaching and learning, especially in primary school. These include online platforms for teachers and learners and various forms of teacher CPD. However, multiple initiatives across and within states, particularly related to teacher CPD, are often not well co-ordinated.

3. Several initiatives have promoted the use of technology to support education, though evidence from the Covid–19 pandemic suggests that most learners have been unable to benefit from opportunities to take part in online learning.

4. English is a compulsory subject, often from Grade 1. A national curriculum is available but is implemented through textbooks, which remain the predominant source of material used by teachers. For many teachers it is likely that there is little distinction between 'curriculum' and 'textbook'. The levels of English assumed in the textbooks used are often beyond the ability of learners and perhaps in many cases also the teachers. Especially, but not only, in the private sector, English-medium instruction is used, but often as a status symbol and not always with a clear understanding of how it might assist or hinder learning.

5. Teaching practices across subjects, including English, remain didactic. In English lessons, typical activities include detailed analyses of written texts using translation and with a focus on vocabulary. While awareness of the importance of speaking and listening skills is increasing, they are not given substantial space during English lessons; in contrast, students spend much time copying information from the board. Classes are multilingual but teachers of English lack the skills to exploit and build on the language resources learners have. Various factors contribute to the persistence of teacher-centred pedagogies. These include limitations in teachers' competences as well as pressures that come from heavily loaded syllabi and demands from parents that teaching and learning follow a certain conventional pattern.

6. Limitations in pre-service teacher education mean that graduates become primary school teachers of English with insufficient subject-specific pedagogical competence and modest levels of English proficiency. Any induction training they receive is generic and does not address gaps in their knowledge and skills. Teachers of English do have access to various forms of CPD provided by government and non-government bodies, though provision and quality vary and there is limited information about which forms of CPD work best in

promoting positive change in the teaching and learning of English.

7. The 2020 National Education Policy establishes a number of principles for improving school education in India and focuses on the importance of teacher quality. Thus, the structure of pre-service programmes is being revised and the CPD allocation for teachers increased. New teacher professional standards are also being introduced. Such measures can contribute to more effective education generally, including for English, but it is important that reform proceeds in an informed manner, guided by an understanding of current barriers to progress in education, aware of international good practice in teacher education and CPD and based on systematic evaluations of reform initiatives. New policies alone will not lead to change in what educational practitioners believe and do.

The report concludes with ten recommendations that reflect on these key findings. Strengthening the English proficiency of teachers will be critical to improve the outcomes of English across the system. Equally important will be revisions to pre-service and CPD activity so that teachers can develop the practical pedagogical skills they need to work in multilingual classrooms and with textbooks that are often too demanding for learners. Generally, more informed decision-making regarding the use of English medium of instruction is needed.

1 Introduction

This report provides an overview of English in the school education system in India. India's Right to Education Act 2009 guarantees free and compulsory education to learners in Grades 1–8 (Department of School Education and Literacy, 2021a), and accordingly this review examines the status of English in India in those grades (which we refer to here as *basic education*). Throughout, we focus on national policy and its implementation, though it must be acknowledged from the outset that individual states across India have their own educational policies and corresponding practices. We seek to capture some of these by citing examples from across the country.

The analysis that follows is based largely on a deskwork review of publicly available educational reports, academic papers and online information. Some key informant interviews were also carried out to supplement the desk work with the voices and perspectives of practitioners involved in specific areas of English education in India. These interviews, while not in any way generalisable, provide the specific practical insight often absent in official documents and allow some gaps in the available literature to be addressed.

The report begins with an overview of education in India generally before focusing in more detail on a range of issues of specific relevance to English language education. Following a discussion of the role of English in India, key educational policies that affect English language education are highlighted. The core section of the report examines the practice of English language teaching, including a discussion of the multilingual context for language learning in India, textbooks and resources, educational technology, teaching methods and assessment. Pre-service education and continuing professional development (CPD) for teachers of English in India are also discussed. The report concludes by highlighting opportunities, challenges and future trends for English education in India that emerge from the analysis presented here.

Key facts about education in India

Population
1.4 billion
(2021)
(Worldometer, 2021)

Political division
28 states
and
8 union territories
(Office of the Registrar General and Census Commissioner India, 2021)

Number of schools
1.5 million
(July 2021) (All Schools in India, 2021)

Private schools
422,000
(July 2021) (All Schools in India, 2021)

Number of learners
260 million
(2019–20) (Department of School Education and Literacy, 2021b; see Figure 1 for gender breakdown)

Number of teachers
9.7 million
(Department of School Education and Literacy, 2021c)

Compulsory education
Grade 1–8
(Department of School Education and Literacy, 2021a)

Enrolment rates
(Net Enrolment Ratio)
(all enrolment rates below are from Department of School Education and Literacy, 2021b)
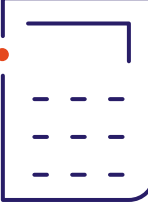
Primary
92.4%

Upper primary
71.9%

Secondary
50.0%

Upper secondary
33.3%

Adult literacy rate
74.4%
(Knoema, 2021)

Expenditure on education (per cent of GDP)
3.5%
(2019–20) (Ministry of Finance, 2021)

2 Education in India

This section, which draws on and updates where necessary a 2019 analysis published by the British Council (Anderson and Lightfoot, 2019), provides an overview of the education system in India (see also Mehendale and Mukhopadhyay, 2019 and, most recently, UNESCO, 2021). This is a very large and complex system, as the indicators shown on the previous page suggest. It is important to note that while a new National Education Policy (NEP) was released in 2020 (Ministry of Human Resource Development, 2020; for an analysis, see Agarwal and Narang, 2021), this has not yet impacted significantly on educational practices around the country. Our focus here, therefore, is on the situation in education and English education in India as it currently stands, although proposed reforms that are of particular relevance will be highlighted.

2.1 Responsibility for education

The Ministry of Education (formerly the Ministry of Human Resource and Development) has overall responsibility for education in India. The educational system, though, is regulated and managed by a complex range of councils and institutes at both national and state level (see Anderson and Lightfoot, 2019:38–9 for an organogram). For example, the National Council of Educational Research and Training (NCERT) (for its 2020 annual report, see National Council of Educational Research and Training, 2020) and the National Council for Teacher Education (NCTE), both based in New Delhi, play central roles in school education (particularly curricula and textbooks) and initial teacher education respectively. Education within states, though, is also regulated by State Councils of Educational Research and Training (SCERTs) and supported at district level by District Institutes for Education and Training (DIETs).
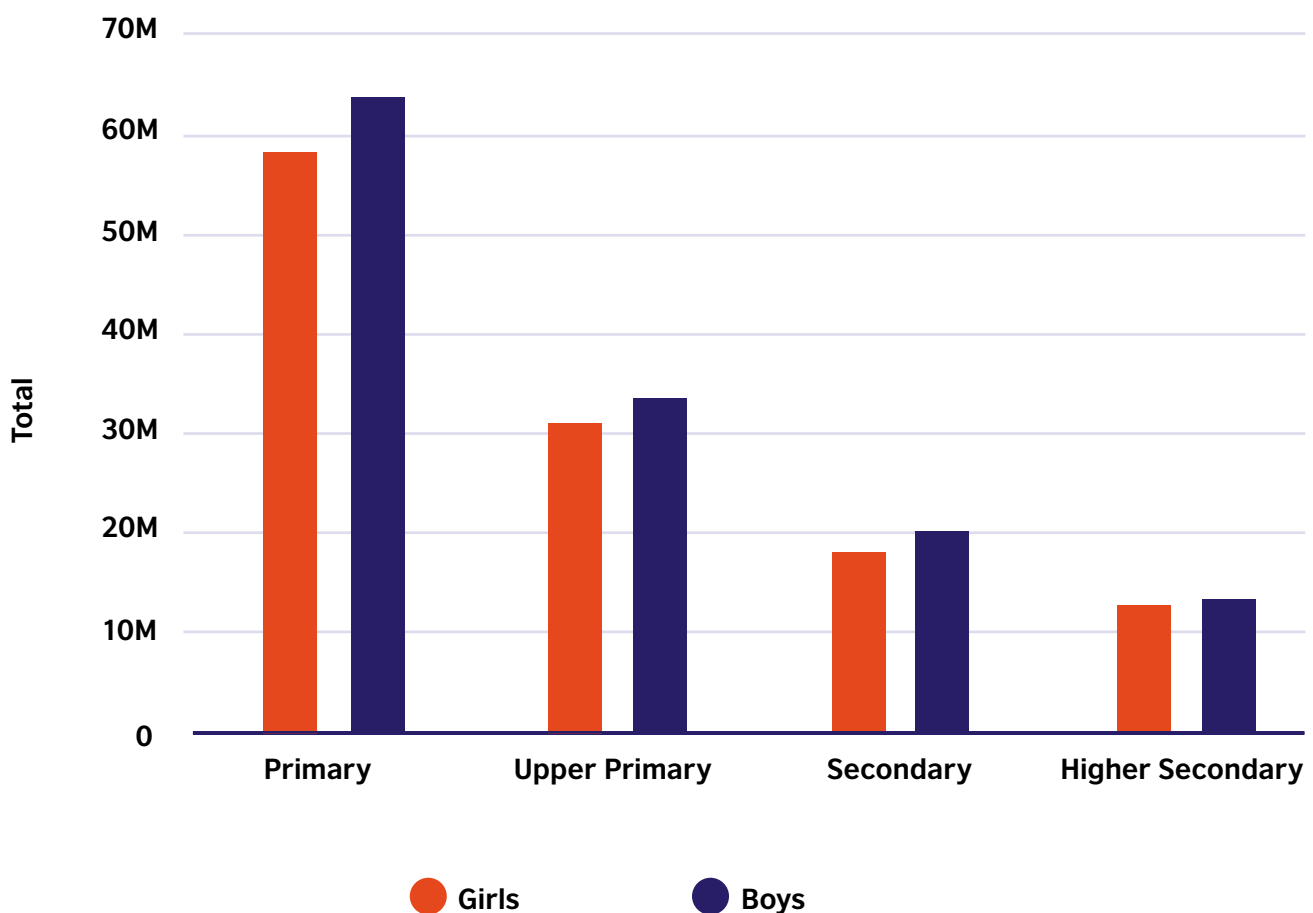
Figure 1: Learners in primary and secondary education in India (Department of School Education and Literacy, 2021b)

2.2 Structure

Education in India is divided into pre-primary (ages 3–6), primary (6–10), upper primary (11–14), secondary (14–16) and higher secondary (17–18).[1] These divisions are not always reflected in practice and variations in the range of age groups present in specific grades have been found, particularly in rural areas.

Schools are classified as either government or private, with the latter being further divided into government aided or unaided (i.e. which receive no financial support from the state). Education is also provided through madrasas and Tribal/Social Welfare Department schools. According to the Department of School Education and Literacy (2021b), students are divided almost evenly between government and non-government schools. Though class sizes vary significantly across the country, the average pupil–teacher ratio for primary schools is 27 and for upper primary it is 19 (Department of School Education and Literacy, 2021c).

2.3 Gender

According to 2018 figures, the adult literacy rate is over 74 per cent (66 per cent of females and 82 per cent of males). Among G20 countries, India has the highest share of adults without primary education (OECD, 2019). While primary enrolment figures for boys and girls are both over 90 per cent, 'the gender gap in educational attainment remains high [in favour of men] across all levels of education' (OECD, 2019:02). India participated in PISA in 2009 but performed badly (72nd out of 73 nations) (ThePrint, 2021) and did not participate in 2012 and 2015. It was planning to participate again in 2021 but this has been postponed until 2022 due to Covid–19 (Exams Daily, 2021).

2.4 Curriculum and assessment

The National Curriculum Framework (National Council of Educational Research and Training, 2005) regulates education provision in the country and school syllabi and textbooks are expected to be aligned with it. Assessment in government schools is designed and delivered largely by teachers, though high-stakes examinations taken at the end of Grades 10 and 12 are managed centrally through various assessment boards.

NCERT views the National Curriculum Framework (NCF) as a broad plan for achieving educational goals. It provides a 'curriculum core' that offers a conceptual structure, which indicates workable principles to guide the development of textbooks and pedagogic practices (National Council of Educational Research and Training, 2006a). Curriculum frameworks are expected to be periodically formulated both at national and state levels. The most recent NCF was released in

2005 and, in principle, this works as an overarching guide for curriculum development across subjects, with flexibility and freedom within states to adapt the framework as necessary and relevant without compromising its basic tenets. But very few states develop their own explicit and independent curricular framework documents. In most cases, curricula appear in the form of brief outlines appended to textbooks, summarising the objectives, pedagogic approaches and assessment schemes to be followed for the given subject. At present, the guidelines of the NCF 2005 are in force, but a new NCF is envisaged in response to NEP 2020. In the past, State Curriculum Frameworks (SCFs) followed the NCF and were developed on the basis of it. However, in the current exercise, SCFs are expected to feed into the NCF. SCERTs have been tasked to prepare SCFs of four kinds – school education, early childhood care and education, teacher education and adult education – which will then be used by a National Steering Committee for the Development of National Curriculum Frameworks, according to a recent press release by the central Ministry of Education (Ministry of Education, 2021b).

2.5 Teachers

According to UNESCO (2021), the workforce in India has a deficit of over one million teachers. The government schoolteacher population is made up of more males (2.7 million) than females (2.1 million) (Department of School Education and Literacy, 2021c), though this gender gap has been closed substantially in recent years. In private schools, though, females total 2.3 million compared to 1.3 million males.

2.5.1 Pre-service teacher education and qualifications

As noted above, responsibility for initial teacher education in India lies with the NCTE and is regulated by the National Curriculum Framework for Teacher Education (NCFTE) (National Council for Teacher Education, 2009). Various teacher qualifications are recognised, such as the Diploma in Elementary Education (DElEd) and Bachelor of Education (BEd). Prospective basic education teachers must also pass the Teacher Eligibility Test (Government of India, 2021a) An important government report (Ministry of Human Resource Development, 2012) noted several problems associated with initial teacher education in India, including a lack of breadth and depth due to its short duration. It was also noted that 'one major area of weakness in existing teacher education programmes is the quality and experience of those who have the responsibility of training young entrants to the profession of teaching' (p.21). In response to the first concern about the duration of initial teacher education in India, the new NEP proposes that a revised (i.e. with a greater focus on developing practical teaching skills)

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1 The 2020 NEP proposes a revised structure of education into ages 3–8 (Foundation), 8–11 (Preparatory),11–14 (Middle) and 14–18 (Secondary).

four-year Bachelor of Education (BEd) be the minimum teaching qualification by 2030. The launch of a new four-year integrated teacher education programme aligned with the NEP was in fact announced in November 2021 (Ministry of Education, 2021a).

2.5.2 In-service teacher education

There is no specific framework for teacher professional development in India, though the NCFTE (National Council for Teacher Education, 2009) does include a chapter entitled 'Continuing Professional Development and Support for In-Service Teachers'. This defines several aims for teacher professional development, including, for example, 'Explore, reflect on and develop one's own practice' and 'Deepen one's knowledge of and update oneself about one's academic discipline or other areas of school curriculum' (p.64). General principles for the design of in-service programmes are also outlined; for example, it is advised that 'interactivity must not be compromised on any account. Large numbers and the use of electronic media in the place of human interaction compromise on the non-negotiable' (p.67). Primary teachers in India, according to the NCFTE, are mandated to complete 20 days of training each year. Three problems with the existing approach to teacher professional development in India were also outlined: teachers in private schools are excluded; teachers have little autonomy in the kinds of professional development they do; and education departments do not 'have any mechanism for co-ordinating the total training being undergone by teachers, with the result there is a lot of over-training, repetition and overlap' (p.71).

For teachers who are newly recruited, induction training of 30 days is funded by Samagra Shiksha Abhiyan (SSA)[2]. In 2017–18, 0.27 lakh (27,000) teachers were approved by MHRD for induction training (Ministry of Human Resource Development, 2018). Such induction programmes focus on general pedagogical issues for teachers and are not subject-specific.

According to UNESCO (2021:115), 'several central institutions such as NCERT, National Institute of Educational Planning and Administration (NIEPA) and state institutions including the State Institutes of Educational Management and Training (SIEMAT), SCERTs, DIETs and BRCs-CRCs, design and offer CPD'. CPD is also provided by NGOs and international educational development organisations such as UNICEF and (particularly for teachers of English) the British Council (see Section 6.7). According to figures cited by Anderson and Lightfoot (2019), 3.5 million teachers in India receive in-service training each year, though provision and quality vary across states and programmes. Generally, though, commentators suggest that official in-service training remains largely top-down and transmissive (Padwad and Dixit, 2014),

with primarily cascade models of delivery (UNESCO, 2021). The new NEP recommends a yearly minimum of 50 hours of in-service training, which gives teachers an element of choice and avoids cascade and other top-down models of training. Covid–19 has also given rise to many opportunities for teachers to pursue professional development through online platforms such as, for example, DIKSHA (https://diksha.gov.in/) and Firki (https://firki.co/), Teach for India's online teacher education platform.

2.5.3 Teacher evaluation and performance standards

An analysis of teacher evaluation in India (Bambawale, Hughes and Lightfoot, 2018) concluded that the importance of this process was recognised and relevant tools to support it are available but that 'uncertainty exists around its purpose and application' (p.29). Thus, for example, while a guide on teacher self-assessment has been published (National Council of Educational Research and Training, 2019a), it is unclear in practice how teachers use this to reflect on their own competences. In a more recent analysis, Pandey (2021) also notes that various approaches to teacher appraisal (such as APAR – Annual Performance Assessment Reports) are applied in India but without any consistency. NEP 2020 has stimulated closer attention to teacher quality, including teacher appraisal, and new draft teacher standards have been published (National Council for Teacher Education, 2021). Four standards are defined: core values and ethics; professional knowledge and understanding; professional practice and competence; and professional development and growth. It will be interesting to monitor how these standards shape teacher evaluation practices in the years ahead; creating new frameworks and tools is important, but these need to be accompanied by support and education that allows teachers and other stakeholders to modify established ideas and practices regarding what counts as teacher quality and how it should be assessed.

2.6 Technology and education

The number of internet users in India rose by over eight per cent to 624 million in 2021 compared to the previous year (DATAREPORTAL, 2021). Recent years have also seen an increasing focus on the role of technology in education as reflected in various national initiatives. These have included 'Digital India' (https://www.digitalindia.gov.in/), SWAYAM (https://swayam.gov.in/) and DIKSHA (https://diksha.gov.in/).

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2 SSA is an over-arching government programme to support the improvement of school education in India; see https://samagra.education.gov.in/features.html

The new NEP also emphasises the importance of technology and states that 'use and integration of technology to improve multiple aspects of education will be supported and adopted' (Ministry of Human Resource Development, 2020:56). Challenges in relation to this goal are also acknowledged, such as ensuring schools have access to electricity (according to the Department of School Education and Literacy, 2021d, 83.4 per cent of schools in India meet this requirement), hardware and software. According to UNESCO (2021), most teachers in India have positive attitudes towards the integration of technology into their work.

Since March 2020, Covid–19 has impacted substantially on education in India (Vegas, Shah and Fowler, 2021). A recent report (ASER, 2020) examined the impact of Covid–19 in rural areas, finding, for example, that 50 per cent of the respondent teachers had received training to support teaching remotely. However, only around 18 per cent of rural students, mostly above Standard 8 and in private schools, attended online classes, with the general conclusion being that, even though 62 per cent of households had a smartphone, 'the impact of digital means of reaching children is not impressive, whether in government schools or private' (p.10). UNESCO (2021:07) reports that smartphones have been the primary technology used by teachers during Covid–19 but, again, notes, that 'a large proportion of students have had limited or no access to devices and data'.

2.7 NGOs in education

Reliable statistics regarding NGOs in India are not available. According to one estimate (Anand, 2015) there are over 3.1 million NGOs operating across the country. While the sector-wise distribution of NGOs is also not accurately known, *Niti Darpan*, the directory of NGOs maintained by the Niti Ayog (formerly the Planning Commission of India), has 130,000 entries. Of these, 73,000 work in education and literacy (Niti Ayog, 2021). It may be safely assumed that the contribution of NGOs to school education in India is quite substantial, though the specific extent of this contribution to English language education is unclear.

A white paper on NGOs by Global Governance Initiative (GGI, 2020) identifies four broad areas of intervention followed by educational NGOs – infrastructure, government advocacy, primary teaching services and human capital development. Based on surveys with the top 32 NGOs, this report concludes that the last two of these areas are where most NGOs focus, while there is less focus on infrastructure and government advocacy. Activity reports from several leading NGOs indicate that, in school education, issues such as literacy, numeracy, access and inclusion are given. NGOs working in education also intervene in many ways, from direct involvement in teaching and learning to advocacy and

research. The Azim Premji Foundation, for example, runs its own lower primary 'demonstration schools' in nine districts in four states (Azim Premji Foundation, 2017). It also has 'field institutes' in 50 districts across six states and one union territory aimed at 'improving the government school education system at the district level' through professional capacity building of stakeholders (Azim Premji Foundation, 2017). Another NGO, Pratham, intervenes both directly (its instructors teaching children in schools and communities) and through partnerships with government teams, and has an extensive portfolio of activities especially in primary education. It also conducts the annual national survey of children's schooling and foundational learning across rural India, leading to Annual Status of Education Reports (ASERs), which are considered key documents on basic literacy and the status of education (Pratham, n.d.). NGOs like Central Square Foundation also work with the government, technology partners and educational entrepreneurs to support initiatives aimed at improving the quality of foundational and basic education. Some other well-known NGOs working in education in India are the Akshara Foundation, Ekalavya, Digantar and Teach for India.

3 The role of English in India

The legacy of English in India can be traced back to the early 17th century via the trade and evangelical missions of the East India Company and Christian missionaries respectively. English began to take a more central position with the introduction of public instruction in English in the 1830s and it became the official language of the Company rule in 1835. It became further entrenched as the language of administration and consequently of prosperity, power and modernity with the establishment of the British colonial rule. Ambivalent positions arose regarding English during India's struggle for independence; it was opposed as the colonisers' language and a 'Westernising' influence, but also valued for the prospects of modernisation and unification it seemed to offer. These tensions continued even after independendence which continued even after independence; the Constituent Assembly in fact spent three years debating the status of English in the free India. These conflicting positions were reconciled in a 'compromise' status of English as an 'associate language', initially for 15 years until 1965, but later indefinitely via the Official Languages Act of 1963. The fact that India does not have a specific 'national' language and that English continues to be formally recognised as a language of administration and education, contrary to the original plans at the Independence, indicate the immense socio-cultural, historical, political and economic complexities besetting languages in India in general and English in particular.

English touches nearly all aspects of the social and personal life of every individual in India, as it is widely used in a range of fields including federal and state administration, legislation and the judiciary, trade and commerce, public services, education and social media. It also has utility as a lingua franca in the vastly multilingual landscape of India. It is therefore seen as the language of opportunity, prosperity and social mobility. In other words, knowledge of English significantly boosts one's social, economic and cultural capital.

A recent survey (Guha, 2021) points out that the centrality of English in a social aspirational space is tied to it being a language of the ruling elite, the emancipatory potential it has and the socio-economic benefits it brings. Higher studies, career and employment opportunities are significantly shaped by a knowledge of English. All high-stakes examinations, whether for entry into prestigious institutions and academic programmes or into high-end public or corporate careers, inevitably include

English proficiency as a key determinant of success (it is therefore somewhat ironic that insufficient attention is paid to the levels of English that teachers of the language should have – see Section 6.7).

The strong demand for English spurred by the software and ICT industries two decades ago still remains high, now thanks to the booming services sector, where even jobs with lower levels of educational requirements still demand some knowledge of English (Endow, 2021). English language skills provide significant returns to those with high proficiency as compared to those without in many sectors of employment (Azam, Chin and Prakash, 2010). Mohan (2014) notes that even when good jobs do not intrinsically require English, the language serves as a kind of gatekeeper. Two reports (Erling, 2014; and Prince and Singh, 2015) also find English proficiency figuring to varying but significant degrees in all major sectors of employment as an important influence on recruitment and career progression.

English also has a strong presence in the cultural life of India, particularly in literature and films, as evidenced by, for example, a large English language publication industry and a substantial readership for Indian writings in English. The widespread use of English by celebrities and luminaries from the cultural world is one example of numerous intangible but powerful influences that continue to uphold the prestige status of English (see Gaekwad, 2017 and various discussions on forums such as Quora[3], for interesting insights into this phenomenon).

3 For example: https://www.quora.com/Why-do-Bollywood-films-have-almost-half-of-the-lines-spoken-in-English-Is-this-how-they-speak-in-India-too.
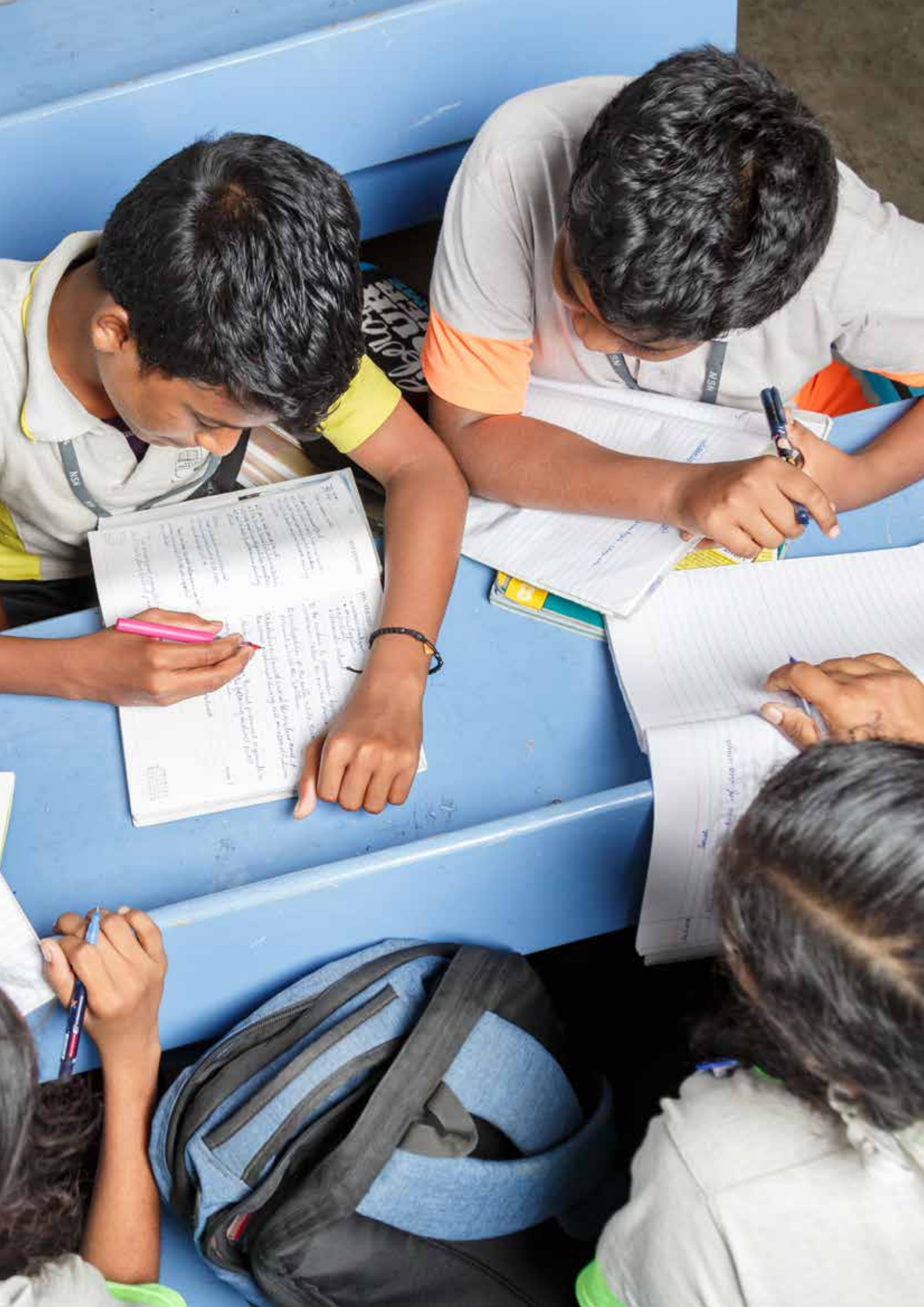
4 Languages and education

English is just one of the hundreds of languages used in India. According to the People's Linguistic Survey of India (2016), there are 780 living languages and potentially 100 unreported languages in India, while Ethnologue (2019) reports 447 living languages in India (both sources above are cited in Bedi, 2020). According to Graddol (2010), estimates of how many Indians speak English vary between 55 and 350 million, while the 2011 India census reported that 260,000 people consider English to be their primary language, 83 million view it as their second language and 46 million as their third. Reliable recent figures for the number of English speakers in the country, though, are unavailable. In terms of proficiency, data is also limited but according to EF's English Proficiency Index, India's position is 48th among 112 countries with an overall proficiency rating of 'moderate' (Education First, 2021). However, the linguistic diversity of the country is so rich and complex that 'people have multilinguality rather than one specific language', according to Agnihotri (2007, 2014) (cited in Heugh et al., 2019:18).

4.1 The Three Language Formula

In terms of policy, language education in India is regulated by the three-language formula, emphasising the study of at least three languages in school, one of which has always been English. Introduced by NEP in 1968 and continued by subsequent NEPs, the formula remains in force with English as a constant feature across the nation, though its implementation differs across states and sectors. Typically, the state language is considered the first language in this formula and English as the second, with various options for the third language, though most states allow students to study other languages, including English, as the first language. However, in all cases, states insist on students taking the state language as one of the three. States usually keep schools not affiliated to the state board out of this mandate, but now there is an increasing tendency to insist on the mandatory teaching of the state language across all schools, irrespective of affiliation, levels or medium of instruction. On the other hand, while all education policies so far have unequivocally favoured other Indian languages as the most preferable medium of school education, English-medium instruction (EMI) has seen a significant rise during the last few years (Nagarajan, 2021). Thus, there are contradictory policy approaches on promoting Indian languages and English across different states.

4.2 English as a subject vs as a medium of instruction

The teaching of English typically starts between Grade 1 and Grade 3 in most states and children generally spend seven to ten years learning English at school. On average, English is taught for about three hours per week at the primary level up to five hours per week at the secondary, with at least one lesson every day. In certain schools and for specific subjects, EMI is used. For example, English-medium schools, which are predominant in the private sector (a point stressed in an earlier analysis of medium of instruction policy in India by Erling et al., 2016), start teaching widely in English from pre-primary years. Other schools are informally known as 'semi-English' medium and in these EMI is introduced later, often from Grade 5 and typically only for mathematics and natural sciences. It is not uncommon to find schools with some classes in the regional medium and others in the English or 'semi-English' medium. Government schools that typically offer education in the regional medium are now increasingly accommodating EMI by converting or adding EMI sections in existing schools and more rarely converting entire schools to EMI or setting up new EMI schools. This is often justified as a response to strong parental demand, but concerns about dwindling enrolments in state-run regional-medium schools are also seen as an important cause behind this move.

Recent statistical surveys illustrate the rise in English-medium schools in comparison to schools with other languages as a medium of instruction in the country. According to 2019 National Statistical Survey data reported in the press (The Indian Express, 2020), the proportion of English-medium students at lower primary level (Grade 1 to 5) went up to 23.2 per cent in 2017–18 from 22.3 per cent in 2014, whereas it went up to 21 per cent from 19.3 per cent at upper primary level. Except for Karnataka, in all southern states of India English was also found to be the most preferred medium of instruction according to another recent survey conducted by the Unified District Information System in 2019 and reported in The Federal (2021).

Sometimes, the spread of English as a medium of instruction is seen as an indication of dilemma and transition caused by the increasing importance of English on the one hand and strong cultural and emotional values attached to Indian languages on the other:

> *While English as a lingua franca gains importance as the language of social and professional mobility, Indian languages hold cultural and emotional value. In some instances, English becomes indigenised and operates as*

an Indian language, evoking emotional and cultural connections through its creolisation. English in these circumstances occupies a liminal place, simultaneously desired and distrusted. The proliferation of private and public schools that advertise education in the English medium is an example of this dichotomy. The teaching of English then requires strategic handling to achieve the aims of a language classroom that strengthens critical literacy in a globalised world. (Jayendran, Ramanathan and Nagpal, 2021:42)

In relation to these tensions between English and local languages, official documents encourage a balance. For example, acknowledging the place of English in the Indian education sector, the Position Paper of the National Focus Group on Teaching of English (National Council of Educational Research and Training, 2006b:01) describes English as 'a symbol of people's aspirations for quality in education and a fuller participation in national and international life'. But it also stresses that English cannot stand alone and must find its place in both regional-medium and English-medium schools along with other Indian languages. This is echoed in the National Curriculum Framework (National Council of Educational Research and Training, 2005:39) as well: 'English needs to find its place along with other Indian languages in different states, where children's other languages strengthen English teaching and learning'. Similar opinions are expressed in Jayendran, Ramanathan and Nagpal (2021:45):

The teaching and learning of English, at this point, must not be seen as an act isolated from the teaching and learning of indigenous languages and their cultures. Instead, the rich narrative, discursive and representational traditions embedded in post-colonial contexts can be leveraged to achieve cultural and critical literacy, in the process of which, operational literacy develops naturally.

4.3 Language mixing in the classroom

Irrespective of the medium of instruction, language mixing is a common practice in the schools in India. This multilingual reality has been clearly documented in a study conducted by Lightfoot et al. (2021) in two different cities of India where the frequent occurrence of language mixing was found in Grade 4 and 5 in English-, Hindi- and Telegu-medium schools in both English and Maths subject classes.

Not surprisingly, the multilingual nature of the society is reflected in both the teacher and student population in classrooms. While students' linguistic resources are considered to have an important positive role in successful learning at school (Heugh et al., 2019), this does not seem to receive enough pedagogical attention in language classrooms. A small study (Goswami, 2004) in 33 primary schools on the medium

of instruction and languages taught in the primary schools of Assam reported that more than 60.6 per cent of the schools were heterogeneous in terms of students' linguistic composition and 75.5 per cent of the teachers used two or more languages in their speech. Two further findings from the same study were that teachers did not receive any training to help them deal with linguistically diverse classrooms and that teachers tended to ignore the linguistic heterogeneity of the classrooms. There are other studies highlighting the lack of preparedness of teachers to deal with linguistic diversity (Borah, 2018) and how teachers encourage students to behave like monolingual speakers (Boruah, 2017). Anderson and Lightfoot (2021:1210) also highlight schoolteachers' reluctance to encourage use of other languages in English language classrooms despite widespread use of translingual practices in daily lives, and advocate for the 'need for explicit focus on use of other languages in Indian English language teacher education' and 'more cohesive support for translingual practices across the education system'.

A timeline of English and English education in India

Secondary education commission – importance of mother tongue and English; English to be taught in all secondary schools

1964–6

1963

1952–3

Kothari Commission – English to serve as link language to higher education; usefulness of the study of English at secondary and higher secondary level; seeds of three-language formula

Official Languages Act – leading to indefinite continuation of English in India

1968

National Education Policy – introduction of the three-language formula, which includes study of Hindi, English and a modern Indian language in school education; emphasis on promotion of both Hindi and English

National Education Policy – emphasis on education in the mother tongue, augmenting materials and resources in Indian languages especially through translations, greater role of universities in strengthening ELT, strengthening of pre- and in-service training of language teachers

District Primary Education Programme – aimed at universal primary education

1976

1987–8

2002

1986

1993

42nd constitutional amendment – education becomes concurrent subject; states in control of English teaching

Central scheme for teacher education – establishment of District Institutes for Education and Training (DIETs)

86th constitutional amendment – addition of right to education

National Focus Group Position Paper on Teaching of Indian Languages – English becoming integral to Indian socio-cultural matrix; acknowledges English as a language of mobility and aspirations; recommends teaching of English interwoven into teaching of Indian languages in multilingual classrooms; foreign languages to be introduced only after the child has gained proficiency in one or more languages

National Focus Group Position Paper on Teaching of English – revisiting aims and challenges of English teaching, proposing new approaches such as multilingualism and language across curriculum, tri-dialectal model; recognises teachers' PD and English proficiency as concerns

2006

National Curriculum Framework – recognition of multilingualism as a resource, stress on language across curriculum, introduction of second language acquisition frameworks and approaches to conceptualise English education

2005

Model school scheme – expanding access to quality education, leading to more English and EMI opportunities

2007–8

Rashtriya Madhyamik Shiksha Abhiyan (RMSA) (National Secondary Education Mission) – objectives include quality enhancement of English teaching, entailing in-service re-training of all secondary teachers

2009

Right to Education Act – economically weaker students get access to private sector (including EMI) schools through 25 per cent quota reserved for them

2009–10

Scheme to provide quality education in madrasas – support to madrasas to introduce English among other subjects; Madrasas to join mainstream school education, including affiliation to education boards

2014

2020

2018

National Education Policy – bilingual teaching-learning materials in mother tongue and English; Three-Language Formula from the foundational stage; funding to alternative schools to introduce English (among other subjects); recommendation to offer all subjects at two levels of 'standard' and 'higher'

Samagra Shiksha Abhiyan (SSA) (Integrated Education Mission merging of SSA and RMSA) – quality enhancement across Grade 1–12 continuum; State Councils of Educational Research and Training (SCERTS) to cover Grades 1-12; SCERTs and DIETs to have separate cells and faculties for English education; English achievement in Grade 10 to be measured through National Achievement Survey

5 English in education structures

5.1 Organisational structure for education

The broad organisational structure that regulates education in India, of which English education forms a part, is summarised in Table 1.

Usually, English language education falls within the purview of the agencies listed in the table with respect to their specific roles. However, there is some diversity at the state level in terms of how these broad structures are further devolved. For example, separate structures for textbook production, examinations, training and research or publications have been set up within the boards of education.

5.2 Departments for English language education

There are also some key institutions and agencies at the national, regional and state levels, which specifically deal with English language education in the school sector. Two Regional Institutes of English (RIE-North at Chandigarh and RIE-South at Bengaluru) undertake in-service education and training of teachers (see Section 6.7.1). Some states also have English Language Training Institutes (ELTIs), while many states have departments or autonomous institutes looking after English education included within the SCERTs.

Table 1: Educational structures and English education

Level	Administrative	Academic	Assessment and Certification
Central	Central Ministry of Education and its various departments	National Council for Educational Research and Training (NCERT), National Institute of Educational Planning and Administration (NIEPA), National Council for Teacher Education (NCTE), Central Advisory Board of Education (CABE), Central Board of Secondary Education (CBSE)	CBSE, National Institute of Open Schooling (NIOS), Council for the Indian School Certificate Examination (CISCE)
State	State Ministries and Directorates of Education	State Council for Educational Research and Training (SCERT), State Boards of Education, Institutes of Advanced Studies in Education (IASEs)	State Boards of Education, State Boards of Open Schooling
District and town/village	District and block education offices	District Institutes of Education and Training (DIETs), Colleges of Teacher Education (CTEs), Block and Cluster Resource Centres	

6 English language teaching in practice

6.1 Textbooks

Though India does have a national curriculum, schools are not compelled to use uniform textbooks until Grade 8 and these vary significantly across states and schools. Many government and government-aided schools follow NCERT/SCERT textbooks for English, while private schools use a wider variety of their own choice, including, in some cases, standard ELT textbooks produced by international publishers. To illustrate these variations, government and government-aided schools in Assam mostly use the textbook series developed by the State Council of Educational Research and Training, Assam (the state academic authority), while regional-medium private schools affiliated to the Secondary Education Board of Assam (SEBA) mostly use their own series of textbooks. Additionally, some CBSE-affiliated English-medium private (usually high-cost) schools follow standard ELT textbooks such as *Snowflakes: Northeast Edition* (Cambridge University Press), *Communicate in English* (Ratna Sagar Pvt. Limited) and *Collins Enriching English Reader*. As a result, the textbooks used for English across the country and within states differ substantially in terms of content, layout and price, providing students with different language learning experiences. Mahapatra (2012:14) describes the 'government-private divide' as 'perhaps the most obvious factor when it comes to class politics in ELT in India,' and differences in the textbooks used in these two sectors are one clear sign of this division.

State boards can exercise their own autonomy in developing textbooks for English and a closer look at the Grade 1 textbooks in three different states (Telangana, Assam and West Bengal) illustrates this. In Telangana state, the textbook *My English World* has seven units connected through the story of a single character, though each unit has a specific theme. The textbook has big pictures and activities for developing listening and responding, vocabulary, reading and writing. In Assam, the textbook (*Beginners' English – I*) has eight lessons (units), each of which has a different topic. Each unit begins with a picture followed by a text or rhyme and a number of activities for developing skills such as listening, speaking, reading, writing and storytelling. West Bengal adopts a different approach – it has integrated the teaching of Bangla, English and Mathematics into a single textbook (*Amar Boi*) rather than using a separate textbook for teaching English. For teaching English, the textbook consists of worksheets addressing, for example, listening, speaking and letter recognition. Besides the lesson content, textbooks often contain notes or instructions for teachers at the end of each lesson/unit (Assam) or towards the end of the textbook (West Bengal).

The Position paper of the National Focus Group on Curriculum, Syllabus and Textbooks (National Council of Educational Research and Training, 2006a) called for the use of 'a package of teaching learning material' rather than a single textbook. However, Indian classrooms, particularly the ones in the government sector, are still largely dominated by the use of textbooks. This dependence on textbooks has been termed a 'textbook trap' by Dutta and Bala (2012).

6.2 Other resources

Other resources available for English classrooms include grammar books, spoken English books and other materials such as chart paper, pictures and worksheets. But the availability and use of these resources vary greatly in different schools and is driven by various factors. For example, one informant working in a private school explained that, though he wanted to draw on a variety of resources for teaching grammar, he was compelled to fall back on traditional grammar exercises from a single grammar book due to pressures by guardians (who believe that having one grammar book to learn is more effective) or the school authorities. On the other hand, a key informant (who is a teacher in a government school) explained that the textbook was self-sufficient and that she did not feel much need to use any other material. It is also commonly the case that materials complementing and supplementing the textbook are not readily available (Meganathan, 2019).

The MHRD Annual Report 2017–18 (Ministry of Human Resource Development, 2018) acknowledges the challenges of making teaching and learning materials (TLM) packages available in government schools, suggesting collaboration with private bodies as a possible solution and highlighting the need for developing clear mechanisms for quality control that can be led by government institutions such as DIETs. However, our desk research did not identify evidence of the form such mechanisms might take in practice.

Some private schools develop a set of TLMs by asking teachers to submit a definite number of TLMs per year, as explained by one of our key informant teachers. Other agencies/institutions are sometimes engaged by the SCERTs and/or the government to design materials for teaching English. For example, SCERT Sikkim was supported by Azim Premji University to revise their English textbooks for Grades 1 to 5 in 2018–19. Government schools in Kerala, Tamil Nadu and Karnataka have been regularly using 20 video films titled 'Hello English' produced by the Regional Institute of English South India (RIESI) for learning English at

primary level. Government and government-aided schools usually procure books including supplementary readers in English through library grants provided by SSA. Many schools have set up reading corners for children with such books with the aim of developing positive reading habits.

Materials are also developed in a responsive manner. For example, to address grey areas in learning outcomes identified by the assessment surveys and programmes such as the National Achievement Survey of 2017, Assam has developed grade-wise and subject-wise Open Education Resources (OERs) for English along with other subjects at primary level using the expertise of resource persons from SCERT, subject experts, SSA, RMSA, CTE and DIET (Government of Assam, n.d.). These materials have attempted to address the learning gaps with the help of case studies and include activities aimed at achieving particular learning outcomes.

States such as Maharashtra and Telangana have developed bridge courses for various subjects including English to help address the learning loss caused by the lockdown period during Covid–19. Such bridge courses help learners review material from the previous grade as well as helping them with content from the current grade. This is meant to provide students with a smooth transition between grades. In Assam, pedagogic support during the pandemic period has included, among others, the supply of learning recovery package for English, worksheets for students in neighbouring schools prepared by DIETs and YouTube videos (Y-Kiran) for students launched by the SSA.

6.3 ICT in English education
The use of ICT in English teaching and learning has gained momentum following the Covid–19 pandemic. The government has formulated eight steps for the implementation of online or digital education, namely PRAGYATA (plan, review, arrange, guide, Yak (talk), assign, track and appreciate). One national digital platform for school education is DIKSHA (Digital Infrastructure for Knowledge Sharing), an initiative of NCERT launched in 2017. Thirty-two states/union territories have uploaded content on the portal so far. Several states have uploaded e-resources related to the textbook content for various subjects, including English, that can be accessed by teachers, students and other stakeholders. For example, SCERT Assam has uploaded e-textbooks for English and practice resources along with interactive content for primary-level students, which the students are supposed to use with the guidance of teachers and guardians. This content is yet to be integrated extensively in schools and only seems to be used sporadically. Limited public information is available to date about the extent, manner and use of such resources for English teaching and learning.

PM eVidya (https://www.swayamprabha.gov.in/index.php/schooledu) is another initiative through which curriculum-based educational content for Grades 1 to 12, developed by NCERT and other agencies such as CBSE, KVS, NIOS, Rotary, etc, is telecast by 12 eVidya direct-to-home (DTH) channels, making the materials accessible to students with limited internet connection. The materials include English.

In Maharashtra, e-content for schoolteachers was developed by the Maharashtra Academic Authority under the Pragat Shaikshanik Maharashtra Programme in 2017 and made available through the Maharashtra In-service Teachers Resource App (MITRA). Later, MITRA materials were incorporated into the DIKSHA portal; however, an evaluation report (Ocansey and Sharma, 2019) observed that the current version of DIKSHA does not have some features that made MITRA popular among teachers (these were not specified in the report).

Despite these large-scale ICT initiatives, limited research is available into the impact they have on the teaching and learning of English. Meganathan (2019) mentions one study that demonstrates how technology had a positive effect on the speaking skills of Grade 6 students in a regional-medium school in West Bengal. However, while the use of mobile phones and digital apps has increased rapidly in India during the pandemic, including for teaching English, studies of the outcomes of these innovations are not yet available.

6.4 Classroom practices
Though there are policy documents and resources available for teaching English, classroom practices, particularly in the government sector, are largely driven by the textbook content without much consideration for policy. Teachers working in government schools do review the learning outcomes occasionally during the teaching process, but find it difficult to attain the outcomes at the respective grades, as reported by the teacher informants, due to very limited exposure of the students to the language outside the classroom and/or insufficient learning at a lower grade. On the other hand, our sources suggest that teachers working at private schools often do not consider the learning outcomes and simply follow the textbook activities and instructions of school authorities.

From discussions with the teacher informants, it can be said that a typical lesson in an English class often begins with a read-aloud activity. Sometimes this is preceded by the teacher giving an idea about the content of the text in the school language, in the belief that doing so will create students' interest in the text. This is followed by translation and/or explanation of texts in the textbooks. Difficult words are written on the board and meanings are discussed or written up. All these activities are mostly teacher-led and students

are expected to follow and listen to the teacher and/or copy the teacher's writing into their notebooks. Rather than helping students complete the language tasks or activities included in a lesson in the textbook, lessons often focus wholly on understanding the content of texts through translation.

Teacher talking time is usually much higher than student talking time in English classrooms. This might be the result of limited pedagogical competence among teachers, in particular a lack of skill in implementing activity-based and learner-centred instruction. As reported by a teacher informant, teachers' efforts are also often constrained by practical challenges such as large classrooms, limited time for completing the syllabus and the low proficiency of students.

Among the language skills, reading and writing are emphasised more than listening and speaking (Dutta and Bala, 2012) in most government schools. Listening and speaking are becoming more prominent (see, for example, The Hindu, 2021, for an article about the introduction of 30 minutes of English speaking in Grades 6 to 12) but generally such developments are not supported by change in curriculum and in the way teachers are trained (Meganathan, 2019). In some private schools, there are separate spoken English classes where activities for improving oral skills are conducted, but practices in conducting such classes are not uniform across schools.

The teaching of reading and writing is often limited to lower-level skills in most government schools. Reading aloud is both taught and assessed until Grade 5 in some schools, as reported by one of the teacher informants. A study (Dutta and Bala, 2012 :34) conducted in eight states/union territories explained the practice of teaching reading as follows:

> Teaching of 'reading' was synonymous with reading aloud by one student or teacher, choral reading, group reading (loud). Textbook was used in more than 90 per cent of classrooms for being read by the teacher and making children listen. Teachers themselves performed 'model' reading without understanding the concept of reading for comprehension. 'Reading', as silent reading at classes III, IV or V level was not observed in any school.

A common problem, also voiced by the teacher informants in this study, is learners' composition skills. Classroom practice is largely dominated by the dictating of notes by teachers due to various reasons such as limited time for 'covering' the syllabus, pressure from school authorities to keep the learners' notebooks error-free and low proficiency of learners. As a result, learners, particularly in government schools, are rarely taught the process of writing.

Practices vary in more challenging contexts. As discussed in Section 4, English classrooms in India are linguistically diverse. Due to teachers' lack of the awareness of appropriate methodological strategies, this diversity becomes a barrier to the process of English teaching and learning. Frustration caused by such challenges combined with the very disadvantaged socio-economic background of the students is reflected in a teacher informant's opinions:

> Teaching English is even more problematic than teaching other subjects …They use a different language variety at home … they even find it difficult to speak the first language used in the school … so this is a challenge to make the transition to English … Rather than using any recommended techniques, I rely on whatever works best to keep them interested in the lesson without much focus on vocabulary or other language points … We do not have any spoken English classes … we actually cannot reach that level … there are many hindrances … students are from poor backgrounds … it is difficult to even bring them to the school.

6.5 Assessment

Considering assessment as an integral part of teaching-learning activities, the Right to Education Act of 2009 mandated the use of Continuous and Comprehensive Evaluation (CCE) for all subjects at primary level[4]. Accordingly, a number of learning outcomes for each grade and subject have been formulated by NCERT as reference points that assessment systems are supposed to use for measuring students' progress qualitatively or quantitatively. For the subject of English, learning outcomes have been spelt out based on separate curricular expectations for lower primary and upper primary stages. For example, one of the Grade 1 learning outcomes is 'identifies characters and sequence of events in a story' (National Council of Educational Research and Training, 2017:25), while for Grade 8, one is 'narrates stories (real or imaginary) and real-life experiences in English' (ibid:39).

Classroom assessment practices, through CCE, are supposed to facilitate the achievement of learning outcomes developed for English in each grade at both lower primary and upper primary levels. The NCERT has developed CCE packages to help teachers understand and implement CCE in teaching-learning with examples of activities for English classes.

It is not clear how far these reforms have been translated into practice in English classrooms. No studies were found during this desk research investigating how effectively CCE had been implemented in English classrooms at the basic education level. However, interviews with key informants (school teachers) align with an observation made in the

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4 CCE was introduced in 2009 but withdrawn in 2017, with plans to reintroduce in 2020–1; see https://www.indiatoday.in/india-today-insight/story/why-the-cbse-introduced-and-then-withdrew-continuous-evaluation-1821304-2021-07-01

Foreword of Continuous and Comprehensive Evaluation Guidelines prepared by NCERT (National Council of Educational Research and Training, 2019b) that there are no visible changes at the ground level probably because of the habit of using tests and examinations as traditional assessment strategies. Teachers tend to equate CCE to the unit tests conducted at regular intervals. Those unit tests actually test the learners' grasp of the syllabus/textbook content rather than measuring their progress in terms of English language level. The teacher informant from a private school shared some practices he follows for continuously assessing spoken English performance of the learners in a separate class hour. However, he did not have any knowledge about learning outcomes or policy directives and just followed instructions from his school authorities. On the other hand, the teacher working in a government school was aware of learning outcomes and CCE because of orientations she received through SSA, but she expressed the need for more guidance on pedagogy for using these ideas in the classroom.

Though there are no other assessment systems exclusively focused on measuring the English language levels of primary-level students, general assessments of some bodies partially include such assessment. For example, along with arithmetic ability, the Annual Status of Education Report (ASER) survey (facilitated by the NGO Pratham and carried out by partner institutions) assesses basic reading ability through tasks designed on the basis of analyses of state textbooks and curricular framework documents. The basic reading and comprehension abilities in English of children aged five to 16 years were assessed by administering the ASER English tool for ASER in 2007, 2009 and 2012. Banerji and Bobde (2013:31) state that the ASER English tool, with five levels for reading and two levels for comprehension, has been used on average with over 522,000 children a year, 'making it perhaps the most widely used basic English assessment for children in the non-English-speaking world'.

The assessment survey results have implications for English learning and teaching in India. For example, according to Banerji and Bobde (2013:31), 'less than half the children in Grade 5 can read simple words in English … and, of the children who can read words, approximately 40 per cent cannot tell the meanings of the words they have read' . This is a clear indication of the need for immediate attention to reading skills in India in both regional language and more so in English. Be it in classroom assessments or other assessment systems, there seems to be very little or no focus on either productive skills (speaking/writing) or on listening.

6.6 NGOs and English

The role of NGOs in education in India was discussed in Section 2.7. In some cases they also provide specific support for the teaching and learning of English. For example, Teach-India, a CSR initiative of The Times of India, runs spoken English development programmes for underprivileged youth. Another NGO, e-Vidyaloka, teaches English among other subjects to rural children of Grades 5–8 through online and digital means. Many education NGOs have their own teaching and teacher training centres, where methodologies and materials developed in-house are put into practice. Similarly, NGOs also develop their own materials and practices for the learning, teaching and assessment of English, which are used in a variety of contexts. Often there is little information about the origins of such materials or practices. The pedagogic soundness and socio-cultural relevance of materials, approaches or practices followed by NGOs, or how they compare or align with those followed in the formal state education system, are issues which need urgent attention, given the large number of entities operating in this space.

Issues of alignment and pedagogic soundness are further aggravated by a common challenge of human resources NGOs all over India face: NGOs typically work with volunteers with no or limited skills, training and knowledge in pedagogy or even subject areas. The GGI white paper (GGI, 2020) cites a report of the Confederation of Indian Industries, which 'indicated the glaring void of skilled workforce in the Indian education NGO space. It was found that Indian NGOs face huge hurdles when it comes to recruiting, training and retaining quality teachers' (Section 4). NGOs functioning without qualified materials producers, curriculum designers and teacher trainers should not be surprising, but is certainly alarming.

6.7 English language teachers

6.7.1 Qualifications

In accordance with the provisions of the Right to Education Act of 2009, the NCTE has laid down minimum entry and academic qualifications for a person to be eligible to be appointed as a teacher at the primary level. One essential qualification is passing the Teacher Eligibility Test (TET) conducted by both the central government and state governments. Passing the Central Teacher Eligibility Test (CTET) helps one to be recruited in central schools, while passing the TET conducted by the state governments helps one to be recruited in the state schools.

TET (an objective-type test) consists of two papers – Paper 1 for those intending to be teachers at the lower primary level and Paper 2 for those intending to be teachers at the upper primary level. A candidate can take both papers. There are two language components in each paper – the first is on the proficiency of the language which is the medium of instruction,

while the other component sees candidates choose from the available options. In states such as Assam, candidates need to take a test of English for the second component in both papers. The syllabus for this component includes aspects of teaching and learning languages and grammar. The syllabus for the lower primary level seems to be a reduced version of that in the upper primary level. This second component carries 30 marks out of the total of 150 marks in the test.

The minimum academic qualifications needed to be a teacher are a senior secondary certificate (or equivalent) for lower primary and graduation at upper primary level. Other than this, candidates need a professional qualification, namely a Diploma in Elementary Education (DElEd) for all grades at primary level or a Bachelor of Education (BEd) for teaching at upper primary level only. Most private schools, however, define their own norms for appointing teachers of English. Besides looking for candidates with a higher degree, many such schools are still seen to consider the BEd as an essential qualification and candidates with a specialised degree for teaching English are often preferred.

6.7.2 Subject specialisation

Teachers in primary schools in India might or might not be subject specialists and different practices are seen in government and private schools. In government schools, generally all teachers at lower primary level need to teach all subjects. Therefore, a teacher with any subject background may teach English at Grades 1–5. However, the Right to Education Act of 2009 mandated the norm of at least one teacher per class for languages at the upper primary level (Grades 6–8). This mandate, in many states, has been implemented so that teachers with an Arts degree teach a range of Arts subjects such as English and Social Science, while those with a Science degree teach Science subjects. In most private schools, though, a teacher with a degree in English/English language is assigned to teach English irrespective of the grade level.

There are few opportunities available for initial teacher training designed specifically for aspiring teachers of English or for newly recruited teachers of English. Whatever training they receive is in the form of limited input on teaching English as part of courses or training programmes meant for all teachers teaching at the primary level. Additionally, evaluations lack a focus on the extent to which pre-service courses sufficiently prepare teachers of English to work in basic education. It is possible, though, that the general observation that 'there is little connection on the ground between … programmes for teacher education with programmes for school education' (Ministry of Human Resource Development, 2015:02) applies to the overly theoretical and academic orientation of pre-service work for English teachers too.

6.7.3 Teachers' English language levels

The English proficiency of teachers is not systematically assessed at the state or the national level, whether at entry into the profession or in-service, and hence it is difficult to present general estimates of teachers' proficiency. Some isolated studies indicate teachers' English levels to be much lower than those in textbooks and curricula. Three needs analysis surveys by the British Council in Maharashtra, Madhya Pradesh and Bihar found that less than ten per cent of the surveyed teachers were at the preferred B2 level of CEFR (British Council, 2013, 2016; Hayes and Raman, 2013).

According to a press report (The Indian Express, 2014) a further British Council analysis in Maharashtra also found that only 39 per cent of teachers at secondary level had the required level of B1 proficiency or above in combined reading, grammar and vocabulary score and only 47 per cent had it in speaking. Also in Maharashtra, estimates based on the observation of teachers in classrooms (rather than tests) have suggested that most teachers were below B1 (Borg, 2018, 2019).

NCERT's Position Paper of the National Focus Group on Teaching of English (National Council of Educational Research and Training, 2006b) recognises the importance of English teachers' proficiency in the language, and in recent years some measures have been taken to address this issue (and that of subject-specific pedagogy training for teachers of English) at pre-service level, particularly through revisions to the Diploma in Elementary Education (DElEd) programme.

The compulsory admission examination for the DElEd programme, known as the Pre-entry Test (PET), now includes a component on 'General English'. Moreover, some additional weight has been given to English language throughout the DElEd syllabus in terms of both proficiency and pedagogy. For example, in the syllabus developed by SCERT Assam (Government of Assam/UNICEF, 2018), eight credits of the 80-credit course have been devoted to proficiency development and pedagogy of English. There is one course each on Proficiency in English in the first and second semester, while in the third semester there is a course on the Pedagogy of English. In the fourth semester there is an optional pedagogy course on the teaching of English (meant for upper primary teachers of English).

The curriculum-syllabus for the DElEd programme (Government of Assam/UNICEF, 2018:03) justifies the inclusion of courses in English pedagogy in the syllabus document as follows:

> *Earlier, the study of English was introduced in upper primary classes in most of the states, but with the increasing use and importance of English its study now starts from Class I itself. Every teacher in primary classes is required to teach two or three languages; therefore,*

courses in the pedagogy of English and regional language have been assigned an important place in the curriculum of the Elementary Teacher Education Programme.

However, the extent to which the proficiency courses in the DElEd programme address the English proficiency needs of teachers requires further investigation. For example, trainees are mostly assessed on reading and writing, while listening and speaking are not given much importance. Hence, it is likely that a gap remains between the stated aims of the proficiency development courses on the programme and the learning that actually takes place.

6.7.4 Postgraduate programmes for English teachers

Higher education programmes in English language teaching are available, though not specifically aimed at teachers at the primary level. For example, the two-year MA in English Language and English Language Teaching at Gauhati University provides, as stated on its website 'professional training to pre-service teachers' of English'. In the fourth semester, it offers a course on practice teaching where student teachers are trained to teach English, particularly at primary level, by engaging in lesson planning and completing a practicum at a local school. Students with any subject background can join the programme after passing an entrance test measuring their English language proficiency. In Assam, some institutions list an MA in English language and/or English language teaching as a desirable qualification for recruiting teachers of English.

Another university offering courses for enhancing English-teaching skills is the English and Foreign Languages University (EFLU), Hyderabad. It offers a Postgraduate Certificate in the Teaching of English (for those with an MA in English or an allied subject) and a Postgraduate Diploma in the Teaching of English (for those who have completed the PGCTE), providing both theoretical and practical knowledge about the teaching of English. Some students who obtain these higher qualifications in English also go on to teach in basic education, though no clear estimates are available on the numbers of such teachers.

6.7.5 Changes under the new National Education Policy

The newly launched National Education Policy (NEP) 2020 has signalled changes in pre-service education. National Professional Standards for Teachers (NPST) have been designed to monitor the design of pre-service teacher education programmes and to help teachers raise professional standards. Recently, the Ministry of Education announced a four-year integrated teacher education programme (ITEP), a dual-major bachelor's degree (an undergraduate degree and teacher education degree) to be offered in around 50 selected multidisciplinary institutions from 2022–3

in pilot mode. This announcement has been made following a mandate of the NEP 2020 that teachers for all school levels (from foundational to secondary stage as per the new structure proposed by NEP 2020) will be engaged only through ITEP from 2030 onwards. This programme will have the dual purpose of preparing aspiring teachers for school education and for higher studies by developing disciplinary knowledge. This seems to be an attempt to address the problem that 'initial training of primary teachers continues to suffer from isolation, low profile and poor visibility in view of it being a non-degree programme' (National Council for Teacher Education 2009:08). While these reforms are not specific to English, they will of course affect all pre-service programmes including those that prospective teachers of English follow.

6.8 Continuing professional development

As noted in Section 2, India does not have a national policy regarding the professional development of teachers generally, which means that CPD provision and practice will vary significantly across states. Examples of government and non-government CPD are discussed below. More broadly, while limited research into the attitudes to CPD of teachers of English in India exists, a study by the British Council in South Asia (British Council, 2015) did find that in India teachers were very interested in improving their English skills, particularly their speaking. They also wanted to improve their knowledge of teaching and learning materials, using technology for teaching and lesson planning. More systematic and up-to-date research, though, is required to better understand the CPD needs of Indian teachers of English. Such research, of course, is of little value unless the identified needs are then used to inform CPD provision in the country.

6.8.1 Government CPD

Regarding in-service training for basic education teachers of English provided by state or district educational authorities, our desk work yielded limited information. For example, NCERT's 2020 report (National Council of Educational Research and Training, 2020) does not refer to any in-service development for teachers of English while the SCERT Delhi website (Government of India, 2021b) has a section on 'In-service Education and Training' but does not include information about any recent activity. A recent book on the teaching of English in India (Jayendran, Ramanathan and Nagpal, 2021) also makes no reference at all to in-service development. Through personal contacts and key informant interviews, though, we were able to obtain some insight into the contemporary situation regarding CPD for teachers of English across the country.

One initial point to make is that the volume of such activity has decreased in the last five years or so, largely due to reductions in the amount of central funding available. Thus, for example, until around

2015, there were over 30 English Language Training Institutes (ELTIs) around the country that received central funding. Since then, these have either closed or merged with the state government. And, to take a specific example highlighted by one of the key informants, until 2016 there existed in Telangana a Districts Centre in-service scheme for teachers of English. This was implemented by the English and Foreign Languages University (EFLU) and initially focused on secondary school teachers (Grades 8–12) although towards the end of the scheme primary teachers were also involved. The scheme consisted of an initial ten-day orientation followed by (for those teachers interested in continuing to study) a three-month training programme at the university. Teachers completing the full programme would then cascade the training to other teachers in their local districts. This has, though, been discontinued. Currently, EFLU continues to provide in-service courses on demand across states, though these are developed responsively rather than as part of any systematic programme.

Government-funded CPD also takes the form of very short and often specific meetings organised by DIETs (within which one officer is typically responsible for English). These are largely informational in nature; for example, teachers might receive updates on policies, the textbook, curriculum or assessment procedures (such training sessions are referred to as 'content-enrichment programmes'). The extent to which such events qualify as CPD is arguable, but they do fulfil the purpose of ensuring teachers are up to date with developments in the teaching of English in their state. DIETs are responsible for the in-service training of English teachers, particularly in states not serviced by Regional Institutes of English (RIEs), which are discussed below. At local levels, Resource Persons placed at Block Resource Centres and Cluster Resource Centres conduct short training programmes for teachers and provide on-site support to teachers through monitoring, classroom observations and development of resource materials. Usually, such resource persons are trained by DIETs and then are supposed to cascade training to other teachers. However, a practising teacher, who was another informant in this project, expressed dissatisfaction with the general support received from such resource persons and believed that external resource persons with more expertise on language pedagogy would have been helpful.

Two RIEs also provide CPD for teachers of English. These are the Regional Institute of English for South India (RIESI, which covers six states in the south of India) and the Regional Institute for English in Chandigarh (which caters for a smaller number of states in the north). Both RIEs offer in-service courses for teachers of English in primary and secondary schools, though their models differ. The RIESI provides (among other distance programmes) an intensive

30-day residential certificate course (moved online recently due to Covid–19), while the RIE in Chandigarh, which also previously adopted an intensive short-course model, has since 2016–7 moved to a more distributed approach; teachers attend training several times in shorter blocks. More detailed information about the work of the RIEs is available on their websites (http://riesielt.org/; http://www.rieni.org/). State school teachers of English do not receive formal recognition for completing in-service courses at RIEs, although achieving a high grade can allow them to apply for a position at their DIET and offers the possibility of working as a Master Trainer on state- or district-level training programmes.

It is not clear how the CPD work of the RIEs is evaluated, but closer study of the in-service programmes they offer would certainly be of value in developing existing provision for in-service teachers of English in India. More generally, further research is needed into the design, delivery and impact of CPD in the country (see, Meganathan, 2019, for a summary of various studies in India that have examined aspects of professional development for teachers of English).

6.8.2 Non-government CPD
Different non-governmental organisations support the CPD of teachers of English in India and examples are discussed in his section.

The British Council
The British Council has worked in partnership with State Education departments across several Indian states, with over 20 projects for primary and secondary teachers listed on the British Council India website (British Council India, 2021a). These projects have been delivered using different models, including cascade training (for example, in the Andhra Pradesh Developing English Language Teaching project) and, more recently, teacher communities of practice (in person and online), such as in the Tejas project in Maharashtra (British Council India, 2021b and Borg, Lightfoot and Gholkar 2020). Mentoring is another model of CPD that has been used, such as on the ELISS project. Generally, projects have focused on improving teachers' confidence in their own English and developing their classroom skills for teaching English. Several projects have also included a capacity-building element through which experienced teachers have had opportunities to develop competences as teacher educators. Most projects seem to have been evaluated, but while impact summaries are included on the British Council India website, evaluation reports do not seem to be publicly available (see, however, a recent external evaluation of the British Council's work in Maharashtra – Ecctis, 2021). In the case of Tejas, a publication called *Stories of Change* (British Council, 2020) is available, which documents, from the perspective of diverse stakeholders, the impact that Tejas has had. Many

thousands of teachers of English have participated in CPD programmes delivered by the British Council in partnership with State Education authorities in India, with support from other UK organisations and consultants.

More recent CPD projects delivered by the British Council illustrate the role that social media can play in facilitating continued interaction and support for virtual teacher communities. For example, in the mentoring phase of the ELISS project, WhatsApp groups were created both for mentors and for each individual mentor and the group of teachers they supported. An analysis of the mentor groups found that these fulfilled a range of social and professional functions (Parnham, Gholkar and Borg, 2018). Given the widespread use of WhatsApp in India (487 million users according to Statista, 2021) and its relatively modest requirements in terms of devices, data and bandwidth, it is clearly a social media platform with potential for supporting CPD among ELT practitioners in India.

TESS-India

TESS-India (Teacher Education through School-based Support in India – https://www.open.edu/openlearncreate/course/index.php?categoryid=45) is another example of non-government support for teachers of English. This was a partnership involving several organisations working with the Government of India's Ministry of Human Resource Development to produce Open Education Resources to improve the classroom practices of primary school teachers in India. For primary English, the project produced modules on several topics including classroom routines, letters and sounds of English, early writing, storytelling and using the textbook creatively. The modules have also been made available in several regional languages. However, insight into the use and impact of such resources on what happens in English lessons in primary schools in India is lacking.

Teacher clubs

Another form of professional development available to teachers of English in India (particularly in Maharashtra) is the Teacher Club model (Padwad and Dixit, 2015; Padwad and Parnham, 2019). This is a form of teacher community of practice defined by:

> … *small, close-knit groups of teachers, characterised by friendliness, informality, an absence of hierarchy and a mixture of amateur and professional interests. They are essentially voluntary groups of teachers coming together to help each other address their concerns and improve themselves as teachers.* (Padwad and Parnham, 2019:556).

Teachers are responsible for managing teacher clubs and deciding what group discussions will focus on. According to Padwad and Parnham, teacher clubs provide for individualised and personalised CPD and

enhance teachers' sense of autonomy. However, sustainability is one key challenge for teacher clubs, particularly because they are not officially recognised by the educational authorities. The informal nature of these CPD groups makes them hard to study in any systematic way; according to one of the authors here and who has been involved with English Teacher Clubs for many years, these groups continue to exist, though in Maharashtra where they originated, only about three or four of the original 20 groups remain active. There is, though, anecdotal evidence that Covid–19 has prompted the growth of a number of informal teacher development groups online.

Teacher associations

English teacher associations (ETAs) are another source of professional development. National ETAs such as AINET, ELTAI and FORTELL offer a range of CPD channels including conferences, courses, action research projects and publications. AINET, for example, supports teachers to develop as trainers, researchers, conference presenters and materials producers, in addition to capacity building in pedagogy and educational technology, through various initiatives. There are also numerous local, regional and university-based ETAs offering opportunities for CPD. However, there is hardly any systematically compiled data on the number, reach or impact of ETAs.

6.8.3 Teacher perspectives

Two of our teacher informants reflected on their experiences of CPD in India. One teacher who works in a government school felt that the pedagogical support she received from the national project (SSA) was very insufficient and the experts in the short-term training provided were not resourceful. She wanted more support in terms of techniques of teaching English to learners with low socio-economic backgrounds in a rich multilingual context. The second key informant worked in a private school, which sometimes organises training programmes for their own teachers by inviting external experts as resource persons. The teacher felt that even though the training they receive often recommends learner-centred pedagogies, parents and guardians are seen to prefer traditional methods such as teachers dictating notes that students copy and school authorities succumb to such pressures. This means that teachers are not able to use innovative ideas in their teaching. Two messages from these informants' experiences relate to (a) the importance of practical CPD content delivered by informed teacher educators, and (b) the need for post-training support that allows teachers to use in their classroom new skills and strategies they obtain through CPD.

7 Opportunities, challenges and future trends

One theme that has recurred throughout this analysis is *diversity;* the English education landscape in India is vast, multi-faceted and almost infinitely varied in a manner that largely defies, other than at the level of national policy, monolithic characterisation. The autonomy that states (and, particularly in the private sector, even schools) have in defining key features of English language education, together with the often-tenuous links that seem to exist between formal policy and actual practice in teaching, learning and assessment, are two factors that contribute to the sense that English education in India is defined by multiple forms of provision.

Tension is another word that captures many of the forces that shape the current English education landscape in the country. National policies compete with those at state level; well-intentioned mandates (such as Continuous and Comprehensive Evaluation) are at odds with the competences teachers possess; textbooks often assume levels of English that are beyond those learners (and probably, in many cases, teachers) have; and educational technology is promoted while teachers and learners lack the equipment and digital skills required to benefit from it.

Much excellent work has taken place, through several national and state-wide projects designed to support teachers of English in various ways and which have been delivered through local educational authorities and bodies, often in partnership with external partners. However, there is little sense of co-ordination and of a framework within which this body of activity creates a coherent whole. This is, perhaps, not wholly surprising given the scale and complexity of India's educational system. The lack of state-level or national policies (such as for teacher professional development) may at times be blamed for this situation, but even where policy and related curricula frameworks do exist (such as for pre-service teacher education or primary education curricula), there is limited evidence that these have assured quality in teaching, learning, assessment and teacher preparation. This suggests, then, that the formulation of policy is not the fundamental problem here and that establishing new policies will not in itself resolve many of the challenges we have highlighted. Thus, for example, while NEP 2020 has mandated that pre-service teacher education move towards a new four-year integrated model, it cannot be assumed that re-designing programmes to meet the new requirements will automatically improve the quality of graduates and of the subsequent teaching they provide. This is perhaps one of the conceptual challenges that needs to be addressed at higher levels of the system; the mistaken belief that new policy will automatically lead to changes in entrenched ideas and practices.

On a practical level, based on our analysis, there are several key themes in English education in India that provide opportunities for further inquiry, deeper understanding and evidence-based interventions. The point about **understanding** is key here because, despite large volumes of activity in English in basic education in India, evidence of its impact remains scarce. Without such insight it is difficult to isolate particular barriers to quality and to suggest appropriate interventions. The following issues merit particular attention:

1. **Curricula for English:** In government schools, curricular decisions are made at state level, based on a national framework, but these amount largely to decisions about which textbooks to use or, where these are produced locally, how to design textbooks. It is commonly (but largely anecdotally) noted, though, that the level of English in the textbooks used in many basic education classrooms is too high for their users. This issue needs to be investigated more closely and if corroborating evidence is found, then a closer analysis of the factors leading to this discrepancy between teacher and learner competence and curricular expectations should be undertaken. Learners who work with curricula that are well beyond their competence will inevitably become demotivated; teachers whose levels are not sufficiently high will also inevitably prioritise pedagogical strategies (such as translation-based text analysis) that fail to optimise the learning of English.

2. **The private sector:** Around 50 per cent of primary school students in India attend private schools. This is a substantial component of India's educational provision, but one that is both less regulated (for example, in terms of textbooks, teacher recruitment and the use of EMI) and sometimes overlooked (for example, government-mandated CPD provision is often not extended to these teachers). There is clearly a need to better understand the private sector and how English education unfolds there; this can highlight effective policy and practice that might be transferrable to government schools, as well as identify limitations in how English is taught and learned in the private sector that need to be addressed. Partnerships between private and government schools also have much potential for supporting English education nationally.

3. **Pre-service teacher education:** Changes promoted by NEP 2020 will be phased in over the next few years, but it is important for this work to be based on an understanding of the features of current initial teacher education programmes that limit their effectiveness. While extending the length of pre-service teacher education will create space for improved teacher learning, the simple allocation of more time will not necessarily generate benefits. It is important to ensure that prospective teachers experience high-quality learning and this must be based on well-designed and delivered curricula, with space for the development of practical teaching skills and clear connections with the realities of schools and classrooms (as opposed to theoretical programmes taught by lecturers with limited knowledge of what classrooms are like). The development of graduates' English language skills also needs to be addressed much more substantially, as the quality of English education is seriously compromised if teachers themselves only have basic English skills. There also needs to be much more emphasis on the development of teacher educator competences, informed, for example, by frameworks such as that developed by the British Council (2022).

4. **Continuing professional development:** There are no national or state-level CPD frameworks and thus provision for teachers generally is uneven and sporadic across the country. Existing provision (for example, by RIEs, DIETs and bodies similar in function to the Regional Academic Authority in Maharashtra) is also not systematically evaluated and reviewed. There are clear opportunities here, therefore, for research that maps current provision at state level, examines its rationale, strengths, limitations and impacts, and works towards understandings of good practice in CPD for primary school teachers of English in India. NEP 2020 advocates a move away from top-down cascade models of in-service training; this is a significant shift and CPD providers at state and district level will benefit from opportunities to develop their understanding of what this means in practice for the design and delivery of CPD. Some of the projects implemented by, for example, the British Council that have used community of practice models may be instructive in this regard. Displacing persistent notions among teachers that CPD equates to formal training courses will be an important part of the changes NEP 2020 is seeking to bring about.

5. **Teacher educator development:** Those who facilitate CPD for teachers of English will also benefit significantly from opportunities to enhance their competences as teacher educators; they are often academically well qualified and hold postgraduate qualifications in ELT, but may not have had opportunities to develop the kinds of competences specific to teacher educators. Given the increase in online CPD, trainers would also benefit from opportunities to develop their skills as online teacher educators.

6. **Teacher competence:** Insufficient information is available about what teachers of English do in basic education classrooms and of the skills and knowledge they need further support with. The range of competences (including as skilled users of English) effective teachers of English require is broad, yet the limited focus on teaching English many basic education teachers will have experienced in their pre-service teacher education most likely means there are significant gaps in how effectively they are able to support the learning of English. For example, the multilingual nature of Indian classrooms means that teachers will benefit from competences that allow them to exploit multiple languages effectively without detriment to any of them. Assessment is another important competence basic education teachers need yet little is known about the processes through which English is assessed in basic education. Teachers, though, are expected to play a central role in the process and to use continuous and formative assessment. The extent to which this occurs, the exact assessment strategies teachers use and the assessment literacy they possess as teachers are all issues where more evidence is required and where interventions will be of value. General observations about the largely didactive nature of teaching in India (UNESCO, 2021) will apply equally to English, and while the limitations of pre-service programmes partly explain this, deeper analyses of the factors responsible for the continued widespread use of teacher-centred pedagogies are needed.

7. **Societal pressures:** Insights provided by our key informant teachers suggest that schools come under external pressure, particularly from parents or guardians, to persist with conventional modes of instruction that focus on rote learning, and that this influences what happens in classrooms. This is an interesting issue to examine in the context of broader analyses of the factors that shape the pedagogical choices of basic education teachers of English. If, for example, teachers must follow

directives issued by headteachers who are in turn influenced by parents, an important dimension of teacher professionalism is being eroded. This may have implications for the kinds of professional support needed by school leaders so they can educate guardians, protect teachers and enable them to improve classroom practices.

8. **Educational technology:** There has been a very visible drive by the government of India to promote wider use of technology in education, including online, in response to Covid–19. Various NGOs have also partnered with educational authorities to support these efforts. Questions remain, though, about the extent to which teachers and learners have access to the skills, confidence, equipment and software they need to make effective use of technology to support English language education, and this merits closer study. There is evidence, too (Borg, 2022), that teacher education departments in India were largely unprepared to move online during the pandemic and it is thus also important to explore teacher educators' needs regarding online delivery and to establish appropriate support mechanisms. Partnerships with NGOs and the private sector are likely to be an important part of efforts to support the wider and more effective use of educational technology by teachers of English and English language teacher educators.

9. **English as medium of instruction:** Here, too, the impression that emerges from this review is one of substantially varied and insufficiently co-ordinated practice regarding the use of English as a medium of instruction in basic education. In the private sector especially (see Erling at al., 2016), EMI is often adopted for the prestige it is seen to bestow on schools (i.e. EMI is used an indicator of quality). This assumption is often unquestioned and influences the choices and expectations of parents. The development of strategies that make informed advice available to parents and guardians regarding the role of English in the education of primary school children in India is thus another measure that can be recommended here.

10. **Teacher evaluation:** The 2020 NEP has stimulated the development of new professional standards for teachers. Again, while the availability of such standards is positive, their formulation must be viewed as an initial and relatively unproblematic step in reforming teacher evaluation practices across the country. In addition to ongoing discussions of what these generic standards mean specifically for teachers of English, there is much work to be done to bring about change in established ideas about what good teachers know and can do, about the purposes and processes of

teacher evaluation, and of the role teachers can play in the process. Unless these issues are systematically addressed by educational authorities, it is unlikely that policy will lead to any practical change.

Author biographies

Simon Borg has been involved in English language teaching and teacher education for over 30 years. He specialises in the design, implementation and evaluation of professional development programmes and policies, and has published over 100 books, chapters and research papers. As a consultant, he has completed assignments related to English language teacher education in over 20 countries. Details of his work and his blog are available at http://simon–borg.co.uk/

Amol Padwad is Professor and Director, Centre for English Language Education, DrBR Ambedkar University Delhi. He is also the secretary of AINET (Association of English Teachers) and a former National President of the English Language Teachers' Association of India. His career of over 35 years includes teaching, training, ELT consultancy and organisational leadership. He pioneered English Teachers Clubs – self-help teacher development groups – in several rural towns of central India. His key publications include *Continuing Professional Development: Lessons from India* (with Rod Bolitho), *Teaching in Low Resource Classrooms: Voices of Experience* (with Richard Smith and Deborah Bullock) and *Research in English Language Education in Indian Universities: A Directory.*

Pranjana Kalita Nath is Assistant Professor in the Department of English Language Teaching in Gauhati University, Assam, India. She teaches Academic Reading, Methodology of Language Teaching and Practice Teaching to postgraduate students. In addition, she delivers sessions on CPD programmes for teachers of English. She completed a PhD in English language teacher education from Gauhati University with financial support from a Junior Research Fellowship received after qualifying in a national-level test (UGC-NET). She has also completed OPEN Alumni CoP Community Lead Training and facilitated a TESOL Methodology MOOC. She is an early career researcher and has published three research articles.

References

Agarwal, A and Narang, P (2021) *National Education Policy 2020: One time comprehensive evaluation*. Centre for Civil Society. New Delhi. Available from: https://ccs.in/images/2021/Monograph_NEP_2020_Centre_for_Civil_Society.pdf [Accessed 14 November 2021].

All Schools in India (2021) *How many government and private schools in India?* [Online]. Available from: https://allschoolsinindia.in/how-many-government-and-private-schools-in-india/ [Accessed 16 November 2021].

Anand, U (2015) India has 31 lakh NGOs, more than double the number of schools. [Online] Available from: https://indianexpress.com/article/india/india-others/india-has-31-lakh-ngos-twice-the-number-of-schools-almost-twice-number-of-policemen/ [Accessed 14 November 2021].

Anderson, J and Lightfoot, A (2021) Translingual practices in English classrooms in India: current perceptions and future possibilities, *International Journal of Bilingual Education and Bilingualism*, 24(8), 1210–1231.

Anderson, J and Lightfoot, A (2019) *The school education system in India: An overview. New Delhi, India.* Available from: https://www.britishcouncil.in/sites/default/files/school_education_system_in_india_report_2019_final_web.pdf. [Accessed 14 November 2021].

ASER (2020) *Annual status of education report (rural) 2020 wave 1*. New Delhi, India. Available from: https://sttar.in/wp-content/uploads/2020/11/Annual-Status-of-Education-Report-Rural-2020-Wave-1.pdf. [Accessed 14 November 2021].

Azam, M, Chin, A and Prakash, N (2010) The Returns to English-Language Skills in India. *IZA Discussion Papers* 4802. Available from: https://www.journals.uchicago.edu/doi/pdf/10.1086/668277 [Accessed 29 November].

Azim Premji Foundation (2017) Schools. [Online] Available from: https://azimpremjifoundation.org/unit/schools [Accessed 24 November 2021].

Bambawale, M, Hughes, J and Lightfoot, A (2018) *Exploring teacher evaluation processes and practices in India: A case study*. New Delhi: British Council. Available from https://www.britishcouncil.in/sites/default/files/exploring_teacher_evaluation_processes_and_practices_in_india_-_a_case_study_final.pdf [Accessed 18 December 2021].

Banerji, R and Bobde, S (2013) Evolution of the ASER English tool, in Berry, V (ed) *English Impact Report: Investigating English Language Learning Outcomes at the Primary School Level in Rural India*. London: British Council, pp. 27–32.

Bedi, J (2020) *English Language in India: A Dichotomy Between Economic Growth and Inclusive Growth*, London and New York: Routledge.

Borah, MP (2018) English for Beginners in Multiple Mother Tongue Classroom Contexts in Primary Schools, in Tomlinson, B and Keedwell, A (eds) *Explorations: Teaching and Learning English in India: Issue 10: Using inclusive practices and multilingual approaches (2).* British Council India.

Borg, S (2018) *Tejas year 2 evaluation report* (unpublished).

Borg, S (2019) *Tejas year 3 evaluation report* (unpublished).

Borg, S. (2022). *COVID-19 and the shift to online language teacher education.* Available from: https://aqueduto.com/resources/our-research/covid-19-and-the-shift-to-online-teacher-education/ [Accessed 1 March 2022].

Borg, S, Lightfoot, A and Gholkar, R (2020) *Professional development through Teacher Activity Groups*. British Council: New Delhi. Available from: https://www.britishcouncil.ro/sites/default/files/teachingenglish_-_professional_development_through_teacher_activity_groups.pdf [Accessed 15 February 2022].

Boruah, P (2017) Learning English in a low-cost semi-urban English-medium school in India: Challenges, interaction patterns and domains of use, in Coleman, H (ed) *Multilingualisms and Development*, pp. 289–306. London: British Council.

British Council India (2013) *Needs analysis report – Maharashtra English language initiative for secondary schools* (ELISS). British Council: New Delhi. Available from: https://www.britishcouncil.in/sites/default/files/needs_analysis_report_-_eliss_2013.pdf [Accessed 20 November 2021].

British Council (2015) *Technology for professional development: access, interest and opportunity for teachers of English in South Asia.* British Council: New Delhi. Available from https://www.teachingenglish.org.uk/sites/teacheng/files/pub_Digital%20Teachers%20Report_FINAL_LOW_RES.pdf [Accessed 18 December 2021].

British Council India (2016) *English in education: Bihar state profile - India*. British Council: New Delhi. Available from: https://www.britishcouncil.in/sites/default/files/bliss_english_profile_report_final_170216.pdf [Accessed 20 November 2021].

British Council (2020) *Tejas stories of change*. Mumbai, Maharashtra. Available from: https://www.britishcouncil.in/sites/default/files/tejas_stories_of_change_english.pdf. [Accessed 16 November 2021].

British Council India (2021a) *Our work in English teaching and learning* [Online]. Available from: https://www.britishcouncil.in/programmes/english [Accessed 16 November 2021].

British Council India (2021b) *Tejas* [Online]. Available from: https://www.britishcouncil.in/programmes/english/primary/tejas [Accessed 16 November 2021].

British Council (2022) *CPD framework for teacher educators.* London: The British Council.

DATAREPORTAL (2021) *Digital 2021: India* [Online]. Available from: https://datareportal.com/reports/digital-2021-india?rq=India [Accessed 30 November].

Department of School Education & Literacy (2021a) *Right to education* [Online]. Ministry of Education, Government of India. Available from: https://dsel.education.gov.in/rte [Accessed 16 November 2021].

Department of School Education & Literacy (2021b) *Udise+ report 2019–20* [Online]. Ministry of Education, Government of India. Available from: https://dashboard.udiseplus.gov.in/#/reportDashboard/stdDashboard [Accessed 16 November 2021].

Department of School Education & Literacy (2021c) *Udise+ report 2019–20* [Online]. Ministry of Education, Government of India. Available from: https://dashboard.udiseplus.gov.in/#/reportDashboard/tDashboard [Accessed 16 November 2021].

Department of School Education & Literacy (2021d) *Udise+ report 2019–20* [Online]. Ministry of Education, Government of India. Available from: https://dashboard.udiseplus.gov.in/#/home [Accessed 16 November 2021].

Dutta, U and Bala, N (2012) *Teaching of English at Primary Level in Government Schools: Synthesis Report.* NCERT and SSA: New Delhi. Available from: https://ncert.nic.in/del/pdf/English_Primary_level.pdf [Accessed 16 November 2021].

Ecctis (2021) *Evaluation of the British Council Programme in Maharashtra*. Available from: https://www.britishcouncil.in/sites/default/files/maharashtra_teacher_development_programme_evaluation.pdf [Accessed 18 December 2021].

Education First (2021) EF English Proficiency Index. Available from: https://www.ef.com/wwen/epi/about-epi/ [Accessed 18 December 2021].

Endow, T (2021) Language and learning: English as a medium of instruction in low-cost private schools. *Economic and Political Weekly,* 56(13). [Online]. Available from: https://www.epw.in/journal/2021/13/special-articles/learning-and-language.html [Accessed 18 November 2021].

Erling, E.J. (2014) *The role of English in skills development in South Asia: Policies, interventions and existing evidence*. British Council. Available from: https://www.britishcouncil.org.np/sites/default/files/role_of_english_in_skills_development_in_south_asia_inside.pdf [Accessed 18 December].

Erling, EJ, Adinolfi, L, Hultgren, AK, Buckler, A and Mukorera, M (2016) Medium of instruction policies in Ghanaian and Indian primary schools: An overview of key issues and recommendations. *Comparative Education*, 52(3), pp. 294–310.

Exams Daily (2021) *PISA postponed by one year, to be held in 2022 MHRD* [Online]. Available from: https://hindi.examsdaily.in/pisa-post-poned-one-year-held-2020-mhrd-notification [Accessed 29 November 2021].

Gaekwad, M (2017) Bollywood has always treated English as a funny language. [Online] Available from: https://scroll.in/reel/837368/bollywood-has-always-treated-english-as-a-funny-language [Accessed on 17 December 2021].

Global Governance Initiative (GGI) (2020) Reimagining education NGOs in India: A success playbook. [Online] Available from: https://www.globalgovernanceinitiative.org/post/reimagining-education-ngos-in-india-a-success-playbook [Accessed 18 November 2021].

Goswami, N (2004) A micro study of medium of instruction and languages taught in the primary schools of Assam. Available from http://www.tezu.ernet.in/project_reports/2021/20-129.pdf [Accessed on 23 November 2021].

Government of Assam (n.d.) Open Educational Resource (OER) as Teachers Helpful Materials. Available from: https://ssa.assam.gov.in/sites/default/files/swf_utility_folder/departments/ssam_medhassu_in_oid_5/this_comm/OER-Concept.pdf [Accessed 18 November 2021].

Government of Assam/UNICEF (2018) Diploma in Elementary Education (DELEd) Curriculum-Syllabus. Available from: https://scert.assam.gov.in/sites/default/files/swf_utility_folder/departments/scert_medhassu_in_oid_6/portlet/level_2/curriculum_syllabus_of_d.el_.ed_.pdf. [Accessed 14 November 2021].

Government of India (2021a) Teacher eligibility test. [Online]. Available from: https://ctet.nic.in/Weblnfo/Page/Page?PageId=1&LangId=P [Accessed 30 November 2021].

Government of India (2021b) *State Council of Educational Research and Training* [Online]. Available from: http://scertdelhi.nic.in/wps/wcm/connect/doit_scert/Scert+Delhi/Home/ [Accessed 30 November 2021].

Graddol, D (2010) *English Next India: The Future of English in India*. New Delhi: British Council.

Guha, R (2021) English language education in India: How aspirations for social mobility shape pedagogy, *Economic and Political Weekly-EPW Engage*, 23 April 2021. [Online]. Available from: https://www.epw.in/engage/article/english-language-education-india-aspirations-pedagogy [Accessed 14 November 2021].

Hayes, D and Raman, UK (2013) *Needs analysis report: Madhya Pradesh English language teacher training*. New Delhi: British Council. Available from: https://www.britishcouncil.in/sites/default/files/mp_need_analysis_report_-_combined_file.pdf [Accessed 20 November 2021].

Heugh, K, French M, Armitage J, Taylor-Leech K, Billinghurst N and Ollerhead, S (2019) *Using multilingual approaches: moving from theory to practice, A resource book of strategies, activities and projects for the classroom*. London: British Council. Available from: https://www.teachingenglish.org.uk/publications-research [Accessed 18 December 2021].

Jayendran, N, Ramanathan, A and Nagpal, S (2021) *Language education: Teaching English in India*. New York: Routledge.

Knoema (2021) *India – adult (15+) literacy rate* [Online]. Available from: https://knoema.com/atlas/India/topics/Education/Literacy/Adult-literacy-rate [Accessed 16 November 2021].

Lightfoot, A, Balasubramanian, A, Tsimpli, I, Mukhopadhyay, L and Treffers-Daller, J (2021) Measuring the multilingual reality: lessons from classrooms in Delhi and Hyderabad, *International Journal of Bilingual Education and Bilingualism,* DOI: 10.1080/13670050.2021.1899123

Mahapatra, SK (2012) The Impact of Content: English Textbook Designing in India. *Language and Language Teaching*. 1 (2). Vidya Bhawan Society and Azim Premji University.

Meganathan, R (2019) Research in English language education in India. *Indian Educational Review*, 57(2). Available from: https://ncert.nic.in/pdf/publication/journalsandperiodicals/indianeducationalreview/IER_July_2019.pdf#page=10 [Accessed 16 November 2021].

Mehendale, A and Mukhopadhyay, R (2019) School system and education policy in India, in Sarangapani, PM and Pappu, R (eds) *Handbook of Education Systems in South Asia* [Online]. Singapore: Springer Singapore. Available from: https://doi.org/10.1007/978–981–13–3309–5_13–1. [Accessed 16 November 2021].

Ministry of Education (2021a) *Ministry of education notifies four-year integrated teacher education programme* [Online]. Government of India. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1766921 [Accessed 29 November 2021].

Ministry of Education (2021b) Ministry of Education forms a National Steering Committee for the Development of National Curriculum Frameworks [Online]. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1756800 [Accessed 28 November].

Ministry of Finance (2021) *Economic survey* 2020–21 (Vol II). New Delhi, India. Available from: https://www.indiabudget.gov.in/economicsurvey/doc/vol2chapter/echap10_vol2.pdf. [Accessed 29 November 2021].

Ministry of Human Resource Development (2012) *Vision of teacher education in India: Quality and regulatory perspective. Report of the high-powered commission on teacher education constituted by the hon'ble supreme court of India, Vol. III*. New Delhi, India. Available from: https://www.education.gov.in/sites/upload_files/mhrd/files/document-reports/JVC%20Vol%203.pdf. [Accessed 16 November 2021].

Ministry of Human Resource Development (2015) *Report of the joint review mission on the centrally sponsored scheme of teacher education [CSSTE].* New Delhi, India. Available from: http://14.139.60.153/bitstream/123456789/11151/1/Report%20of%20the%20Joint%20Review%20Mission%20on%20the%20Centrally%20Sponsored%20Scheme%20of%20Teacher%20Education%20%5BCSSTE%5D%20Sep%2010-21_2015..pdf [Accessed 16 November 2021].

Ministry of Human Resource Development (2018) Annual Report 2017–18. Available at http://14.139.60.153/bitstream/123456789/13683/1/MHRD%20AR-2017-18%20English.pdf [Accessed 18 November 2021].

Ministry of Human Resource Development (2020) National Education Policy 2020. New Delhi, India. Available from: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf [Accessed 16 November 2021].

Mohan, P (2014) The road to English: Slow migration of the economically weak child to elite India. *Economic and Political Weekly,* 49(7). [Online]. Available from: https://www.epw.in/journal/2014/7/commentary/road-english.html [Accessed 18 November 2021].

Nagarajan, R (2021) 26% of schoolkids in English medium; nearly 60% in Delhi. *The Times of India*, July 3, 2021. Available from: http://timesofindia. indiatimes.com/articleshow/84082483.cms?utm_ source=contentofinterest&utm_medium=text&utm_ campaign=cppst [Accessed 18 November 2021].

National Council of Educational Research and Training (2005) *National curriculum framework*. New Delhi, India. Available from: https://ncert.nic.in/pdf/nc-framework/ nf2005-english.pdf [Accessed 22 November 2021].

National Council of Educational Research and Training (2006a) *Position Paper: National Focus Group on Curriculum, Syllabus and Textbooks*. New Delhi. Available from: http://14.139.60.153/ bitstream/123456789/196/1/Doc-NATIONAL%20 FOCUS%20GROUP%20ON%20CURRICULUM%2c%20 SYLLABUS%20AND%20TEXTBOOKS.pdf [Accessed 22 November 2021].

National Council of Educational Research and Training (2006b) *Position Paper: National Focus Group on Teaching of English*. Available from: https://ncert.nic.in/ pdf/focus-group/english.pdf [Accessed 15 November 2021].

National Council of Educational Research and Training (2017) *Learning Outcomes at the Elementary Stage*. Available from: https://ncert.nic.in/pdf/publication/ otherpublications/tilops101.pdf [Accessed 18 December 2021].

National Council of Educational Research and Training (2019a) *Teacher's Self-Assessment*. Available from: https://ncert.nic.in/pdf/announcement/TSAR.pdf [Accessed 18 December 2021].

National Council of Educational Research and Training (2019b) *Continuous and Comprehensive Evaluation Guidelines*. NCERT: New Delhi.

National Council of Educational Research and Training (2020) *NCERT Annual Report 2019–20. New Delhi, India*. Available from: https://ncert.nic.in/pdf/annualreport/ Annual-Report-2019-20.pdf [Accessed 18 December 2021].

National Council for Teacher Education (2009) *National curriculum framework for teacher education*. New Delhi, India. Available from: https://ncte.gov.in/Website/PDF/ NCFTE_2009.pdf [Accessed 18 December 2021].

National Council for Teacher Education (2021) *National Professional Standards for Teachers*. Preliminary Draft Version 01.08. Available from: https://ncte.gov.in/WebAdminFiles/PublicNotice/ Hindi_0_17_11_2021_637727482281976435.pdf [Accessed 18 December 2021].

Niti Ayog, Government of India (2021) *NGO Darpan (live)* [Online]. Available from: https://ngodarpan.gov.in/index. php/home/sectorwise [Accessed 14 November 2021].

Ocansey, TS and Sharma, A (2019) *DIKSHA in Maharashtra; Needs Assessment Report. ICT India Working Paper 5*. Center for Sustainable Development. Columbia University. Available from: https://csd. columbia.edu/sites/default/files/content/docs/ ICT%20India/Papers/ICT_India_Working_Paper_5.pdf [Accessed 29 November 2021].

OECD (2019) *Education at a Glance 2019: India* [Online]. Available from: https://www.oecd.org/education/ education-at-a-glance/EAG2019_CN_IND.pdf [Accessed 29 November 2021].

Office of the Registrar General & Census Commissioner India (2021) *Administrative Divisions* [Online]. Available from: www.censusindia.gov.in/census_and_you/ administrative_division.aspx [Accessed 16 November 2021].

Padwad, A and Dixit, K (2014) 'Continuing professional development policy 'think tank': An innovative experiment in India', in Hayes, D (ed) *Innovations in the Continuing Professional Development of English Language Teachers*. London, England: British Council, pp. 249–268.

Padwad, A and Dixit, K (2015) 'Exploring continuing professional development: English teachers' clubs in central India', in Wright, T and Beaumont, M (eds) *Experiences of Second Language Teacher Education*. London: Palgrave Macmillan, pp. 153–174.

Padwad, A and Parnham, J (2019) 'Teacher networks in the wild: Alternative ways of professional development', in Walsh, S and Mann, S (eds) *The Routledge Handbook of English Language Teacher Education*. Oxford: Routledge, pp. 553–569.

Pandey, A (2021) Teacher performance appraisal at school: a critical analysis. *Horizons of Holistic Education*, 8(1), pp. 32–39. Available from: https://www. researchgate.net/publication/351130961_Teacher_ Performance_Appraisal_at_School_A_Critical_Analysis [Accessed 18 December 2021].

Parnham, J, Gholkar, R and Borg, S (2018) Using WhatsApp for peer support in a mentoring programme. *The Teacher Trainer*, 32(1), pp. 1–7.

Pratham (n.d.) *Annual Status of Education Reports* [Online]. Available from: https://www.pratham.org/ resources/publications/ [Accessed 24 November 2021].

Prince, E-S and Singh, SM (2015) *English skills for employability: Setting common standards*. British Council. Available from: https://www.britishcouncil. in/sites/default/files/esfe_report.pdf [Accessed 18 December 2021].

Statista (2021) *Number of WhatsApp users in selected countries worldwide as of June 2021* [Online]. Available from: https://www.statista.com/statistics/289778/ countries-with-the-most-facebook-users/ [Accessed 16 November 2021].

The Federal (2021) Preference of English-medium instruction rises in South India except Karnataka. Available from: https://thefederal.com/education/ preference-of-english-medium-instruction-rises-in- south-india-except-karnataka [Accessed 16 November 2021].

The Hindu (2021) Teachers for clear-cut guidelines on 'Spoken English' classes. Available from: https://www. thehindu.com/news/cities/Tiruchirapalli/teachers- for-clear-cut-guidelines-on-spoken-english-classes/ article36762152.ece [Accessed 16 November 2021].

The Indian Express (2014) English proficiency of govt school students, teachers abysmal. https:// indianexpress.com/article/cities/mumbai/english- proficiency-of-govt-school-students-teachers-abysmal [Accessed 29 November 2021].

The Indian Express (2020) Share of kids in English medium steadily up, dips in poorer states. Available from: https://indianexpress.com/article/education/ english-medium-schools-national-statistical-office- native-languages-6514045/ [Accessed 29 November 2021].

ThePrint (2021) India prepares hard for global student assessment test — last time it finished in bottom two [Online]. Available from: https://theprint. in/india/education/india-prepares-hard-for-pisa- global-student-assessment-test-last-time-it-finished-in- bottom-2/316843/ [Accessed 29 November 2021].

UNESCO (2021) *No teacher, no class: state of the education report for India*. Available from: https:// unesdoc.unesco.org/ark:/48223/pf0000379115 [Accessed 18 December 2021].

Vegas, E, Shah, S and Fowler, B (2021) *Ed tech and educational opportunity during the COVID-19 school closures: A case study of Chennai, Tamil Nadu*. Washington, DC. Available from: https://www.brookings. edu/wp-content/uploads/2021/08/Ed-tech-and- educational-opportunity-during-COVID-19-school- closures-FINAL-1.pdf. [Accessed 16 November 2021].

Worldometer (2021) *India Population (live)* [Online]. Available from: www.worldometers.info/world- population/india-population/ [Accessed 16 November 2021].

This report provides an overview of how English language teaching, learning and assessment are currently situated within school-level education in India. The report provides up-to-date contextual information, exploring policies and practices. The authors draw on policy documentation, research studies and a small number of interviews and focus groups to provide an overall picture of the current scenario. They provide commentary on the status of English within the curriculum, classroom practices, how teachers are supported to develop their skills and knowledge and the opportunities, challenges and future trends that the authors have extrapolated from their research.

DEPARTMENT OF GEOGRAPHY

GAUHATI UNIVERSITY

PUBLICATIONS
BOOK CHAPTERS

2021-2022

SL. No	Title of the Chapter	Title of the book/Conference proccedings	Name of the Authors	Editor(s)	Publisher (National/Intern)	Year of the Publication	ISBN No
			List of books and chapters in edited volumes published during the year 2021-22				
1	Assessment of Jiadhal River Basin Using Sedimentary Petrology and Geospatial Approach	Climate, Environment and Disaster in Developing Countries	AkangshaBorgohain, KusumborBordoloi, Dhrubajyoti Sahariah, Santonu Goswami, Anup Saikia, and Ashok Kumar Bora	Narayan Chandra Jana, R. B. Singh	Springer (International)	Feb, 2022	978-981-16-6966-8
2	Urban Flooding Scenario and Human Response in Guwahati, India	Climate, Environment and Disaster in Developing Countries	Sutapa Bhattacharjee, Bimal Kumar Kar	Narayan Chandra Jana, R. B. Singh	Springer	Feb, 2022	978-981-16-6966-8
3	Runoff Estimation of the Kolong River Basin in Assam, India Using NRCS-Curve Number Method and Geospatial Techniques	Drainage Basin Dynamics: An Introduction to Morphology, Landscape and Modelling	Manash Jyoti Bhuyan, Debashree Borah, Binod Kumar Nath, Nityananda Deka, and Ashok Kumar Bora	Pravat Kumar Shit, Biswajit Bera, Aznarul Islam, Sandipan Ghosh, Gouri Sankar Bhunia	Springer International	Jan, 2022	978-3-030-79634-1
4	The Misings of Assam in the Midst of Tradition and Modernity: A Comparative Study of Selected Rural and Urban Areas	Practising Cultural Geographies, Essays in Honour of Rana P. B. Singh	Pahari Doley, Bimal Kumar Kar	Ravi S. Singh, Bharat Dahiya, Arun K. Singh, Padma C. Poudel	Springer	May, 2022	978-981-16-6415-1
5	Population growth and demographic changes in Assam	An Illustrated Geography of Assam	Bimal Kumar Kar	A. K. Bora and M. Nath	EBH Publishers (India)	2022	978-93-92038-433
6	Tourism in Protected areas	An Illustrated Geography of Assam	Prasanta Bhattacharya	A.K. Bora and M. Nath	Eastern Book House	2022	978-93-92038-43-3
7	Rural Hydrological Environment of the Brahmaputra Valley, Assam: A Micro-Observation	North East India: Physical Landscape and Environment	Manash Jyoti Bhuyan and Nityananda Deka	Ashok Kumar Bora, Krishna Das	EBH Publisher	2021	978-93-90434-69-5

8	Traditional water management System and Agricultural Sustainability in a Himalayan Foothills Village of Assam, India	Habitat, Ecology and Ekistics Case Studies of Human-Environment Interactions in India	Sourav Saha, N. Deka, and A. K. Bhagabati	Rukhsana, Anwesha Haldar, AsrfulAlam, LakshminarayanSatpati	Springer	2021	978-3-030-49115-4
9	Char Landscape of the Brahmaputra Riverine Tract, Assam: Elements of Evaluation and Cultural Ecology	Practising Cultural Geographies, Essays in Honour of Rana P. B. Singh	Abani Kumar Bhagabati, Nityananda Deka	Ravi S. Singh, Bharat Dahiya, Arun K. Singh, Padma C. Poudel	Springer	May, 2022	978-981-16-6415-1
10	Estimating Erosional and Aggradational Changes in the Riverine Island Majuli using Landsat Data	Hydrology: Application of Remote Sensing and GIS	KusumborBordoloi Durlov Lahon Debashree Borah Krishna Priya Gogoi Manash Jyoti Nath Dhrubajyoti Sahariah	Niranjan Bhattacharjee	Synergy Book India		978-81-944668-7-1
11	Wetlands of Brahmaputra Floodplain	An Illustrated Geography of Assam	Dhrubajyoti Sahariah, Kuleswar Sinha	A. K. Bora and M. Nath	EBH Publishers (India)	2022	978-93-92038-433
12	Rural and Urban Settlements	An Illustrated Geography of Assam	Manash Jyoti Nath	A. K. Bora and M. Nath	EBH Publishers (India)	2022	978-93-92038-433
13	Rivers	An Illustrated Geography of Assam	Ashok Kr. Bora and Kastury Borkotoki	A. K. Bora and M. Nath	EBH Publishers (India)	2022	978-93-92038-433
14	Assessment of morphometric characteristics and LULC pattern of the Leco water shed, North east India	Advances in Scientific Approach for Sustainable Development	Dhanjit Deka, Hemanta Kumar Medhi	Manoj Borthakur and Mridul Kr. Borthakur	Akinik Publications, New Delhi	2021	

Chapter 25
Assessment of Jiadhal River Basin Using Sedimentary Petrology and Geospatial Approach

Akangsha Borgohain⬤**, Kusumbor Bordoloi**⬤**, Dhrubajyoti Sahariah**⬤**,**
Santonu Goswami⬤**, Anup Saikia, and Ashok Kumar Bora**

Abstract The river Jiadhal is one of the significant right bank tributaries of the Brahmaputra. It starts from the Arunachal Himalaya, crosses a few km through Arunachal Pradesh and enters the Brahmaputra valley (Assam part) near Jiadhal-mukh of Dhemaji district, Assam. The river Jiadhal recurrently inundates vast areas of its basin during the monsoon and put a significant impact on the people and their livelihood. This river carries a huge amount of sediment load and debris triggered by continuous and heavy rainfall within the basin mainly in the upper catchment region causing severe loss of fertile agricultural land and infrastructure of the basin. This study aims to analyze the morphological characteristics of the river Jiadhal using sedimentary petrology, Remote Sensing techniques and Geographic Information System (GIS). The study gives a better prospect toward understanding the morphometric characteristics and sediment dynamics of the basin. It will help the concerned authorities for better planning and mitigation of the issues related to this river.

Keywords River basin assessment · Jiadhal River · Sedimentary petrology · Remote sensing · GIS

A. Borgohain · K. Bordoloi (✉) · D. Sahariah · A. Saikia · A. K. Bora
Department of Geography, Gauhati University, Guwahati, Assam, India
e-mail: kusumbor@gauhati.ac.in

D. Sahariah
e-mail: dhrubajyoti@gauhati.ac.in

A. Saikia
e-mail: asaikia@gauhati.ac.in

A. K. Bora
e-mail: ashokkumarbora@gauhati.ac.in

S. Goswami
Earth and Climate Science Area, National Remote Sensing Centre, Indian Space Research Organization, Hyderabad, India
e-mail: goswami_s@nrsc.gov.in

Chapter 27
Urban Flooding Scenario and Human Response in Guwahati, India

Sutapa Bhattacharjee and **Bimal Kumar Kar**

Abstract Rapid growth of Guwahati, the largest urban center in India's north-east, in terms of area, population, and functionality, is contributing to the complexity of the urban environment. Although due to the influence of monsoon the amount of rainfall in the city almost remains same, it has undergone distributional change, with decrease in rainy days and increase in high intensity rain events. Variety of factors typical to the dynamic environment of Guwahati characterized by surrounding hills, Brahmaputra flowing through it, the ever-expanding concrete surface, and high-rise buildings amidst somewhat rugged terrain across the city; induces severe urban flooding problems. The gravity of the situation can be marked by the fact that, moderate to heavy rainfall for about 2–3 h often results in high intensity urban flooding during the monsoon season. It has become a recurring problem which even transcends to be devastative in certain localities within the city and the life and living of the city dwellers become deplorable. Therefore, this study attempts to analyze the flooding pattern in Guwahati with respect to its intensity, identify the major causes and consequences associated with it, and understand the human response to deal with the resulting situation; primarily on the basis of field observation and investigations.

Keywords Rainfall behavior · Topography · Urban flooding · Flood intensity · Human response

27.1 Introduction

Urbanization could presently be assumed as one of the most dynamic phenomena globally. The intensive structural and functional characteristics of urban spaces embark a sharp contrast with their surroundings, developing them into a unique

S. Bhattacharjee (✉)
Department of Civil Engineering, Indian Institute of Technology Guwahati, Guwahati, India

B. K. Kar
Department of Geography, Gauhati University, Guwahati, India
e-mail: bimalkar@gauhati.ac.in

Runoff Estimation of the Kolong River Basin in Assam, India Using NRCS-Curve Number Method and Geospatial Techniques

Manash Jyoti Bhuyan, Debashree Borah, Binod Kumar Nath, Nityananda Deka, and Ashok Kumar Bora

Abstract

Rainfall and runoff contribute significantly to the functioning of the hydrological cycle and thus constitute the most integral components of the hydrological environment of a region. The surface runoff generated basically by rainfall is highly responsible for floods in the floodplains of a river basin. Therefore, it is very important to find out the complex and intricate rainfall-runoff relationship of a river basin in order to understand its hydrological environment, on the one hand, and to manage the associated fluvio-geomorphic problems on the other. The estimation of runoff also helps in watershed management practices. The present paper is, therefore, an attempt to investigate and estimate the surface runoff of the Kolong river basin in Assam considering the rainfall data series of 2004–2018. An analysis of runoff frequency assessment has been carried out in the study to examine the probabilities of occurrence and their corresponding recurrence intervals attached to the estimated runoff magnitudes of the basin. The Natural Resource Conservation Service Curve Number (NRCS-CN) model has been applied integrating with the Remote Sensing and GIS techniques to estimate and predict the runoff volume based on the rainfall pattern of the given years. The curve number (CN) method, also known as the hydrological soil cover complex, takes into consideration several properties of a basin, like soil permeability, land use, and antecedent moisture conditions (AMCs). In this regard, streamflow, hydrologic soil groups (HSGs), slope, and land use land cover maps have been generated using satellite images in a GIS environment. However, the CN parameter values corresponding to various HSGs and land use and land cover conditions of the basin have been selected from the NRCS standard table.

M. J. Bhuyan (✉)
Department of Geography, Nowgong Girls' College, Nagaon, India

D. Borah
Department of Geography, Arya Vidyapeeth College, Guwahati, India

N. Deka · A. K. Bora
Department of Geography, Gauhati University, Guwahati, India

B. K. Nath
Assam Survey & Settlement Training Centre, Guwahati, India

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   (2022) Advances in 21st Century Human Settlements, pp. 369-399.

1) https://www.scopus.com/inward/record.uri?eid=2-s2.0-85130776683&doi=10.1007%2f978-981-16-6415-1_15&partnerID=40&m
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Population Growth and Demographic Changes

Bimal K. Kar

Introduction

With a long history of peopling and a diverse ethno-religious and linguistic composition and varied socio-cultural practices, the state of Assam is characterized by a very high rate of population growth which has been higher than the country's average growth almost throughout the twentieth century. At the beginning of the century the state's population was 3.29 million and it increased to 8.03 million in 1951 and 31.2 million in 2011 experiencing an average annual growth rate of 1.80 per cent during 1901-1951 and 2.29 per cent during 1951-2011 as against the country's corresponding growth rates of 0.83 per cent and 2.04 per cent. As a consequence, the share of state's population to the country's total increased from 1.38 per cent in 1901 to 2.58 per cent in 2011 through 2.22 per cent in 1951. Despite prevalence of almost similar birth and death rates as in the country, the considerably high growth rates of population in the state had been due to both natural increase and significant volume of migration from both within and outside the country (Kar, 1995 and 2002). Such a high growth rate of population which is also reflected in the process of peopling in the state has a number of far reaching demographic implications including the changes in the ethno-linguistic and religious composition of population in the state.

Peopling and ethnic composition

The peopling process of Assam witnessed several waves and streams of

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Tourism in Protected Areas

Prasanta Bhattacharya

Background

Protected areas, especially national parks and sanctuaries are formalized for territorial protection of outstanding natural phenomena or cultural relics. Apart from opportunities of scientific research, education and understanding natural biota and its value for man, there are also other important reasons that give such areas a competitive economic advantage over other type of land use, like agriculture. Due to the local unique characteristics of such areas along with the growing scarcity value make them highly valuable resource that can be effectively marketed through tourism. As Assam forms a part of global biodiversity hot spot having as many as 7 national parks and 16 wildlife sanctuaries, ventures of tourism may prove to be more effective in managing these protected areas. The article aims at highlighting the genesis of parks and sanctuaries in Assam, their present position along with possible role of tourism in managing such protected areas.

Introduction

Evolution of the modern concept of protected areas can be dated back to the setting aside of Yellowstone National Park in the United States of America in 1872 (Child, 1992). It is an approach to formalizing the age-old custom of preserving areas of particular natural significance, often as exclusive hunting reserve or sanctuaries that bear a public right to free or cheap access. Protected areas, especially national parks are formalized for territorial protection of outstanding natural phenomena or cultural relics. The secondary functions of such protected

Rural Hydrological Environment of the Brahmaputra Valley, Assam: A Micro-Observation

Manash Jyoti Bhuyan
Nityananda Deka

Introduction

The concept of 'rural hydrology' has newly emerged in the field of geography to study the hydrological environment of rural areas (Uchida and Ando, 2003; Asada, 2012) and their impact on the concerned physical settings and human societies of a region. This concept can be applied as an approach in geographical research (Uchida *et al.*, 2005) to understand the evolution, components and mechanism of the hydrological system in village environment and also to analyse the human response to the changing hydrological situation (Bhuyan, 2018). Rural hydrology encompasses the study of hydrological characteristics molded by different wetlands, flood water level on agricultural fields, surface and sub-surface water conditions and mechanism of hydrological cycle. It also incorporates the study of utilization pattern and management practices of water resources, nature of human adaptation and the impact of human societies on the hydrological environment, especially within a micro-rural setting. It is important to note that the rural hydrological approach helps in mitigating many rural ecological and socio-economic problems (Uchida *et al.*, 2005; Asada, 2012) emerged as a result of some irrational and unplanned anthropogenic activities and so-called developmental processes.

Documents

1)   Saha, S., Deka, N., Bhagabati, A.K.
      [Traditional Water Management System and Agricultural Sustainability in a Himalayan Foothill Village of Assam, India](#)
      (2021) Advances in Asian Human-Environmental Research, pp. 279-292.

1)   https://www.scopus.com/inward/record.uri?eid=2-s2.0-85093961580&doi=10.1007%2f978-3-030-49115-4_16&partnerID=40&m
      DOI: 10.1007/978-3-030-49115-4_16

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1)   Bhagabati, A.K., Deka, N.
   [Char Landscape of the Brahmaputra Riverine Tract, Assam: Elements of Evolution and Cultural Ecology](#)
   (2022) Advances in 21st Century Human Settlements, pp. 141-166.

1)   https://www.scopus.com/inward/record.uri?eid=2-s2.0-85130844597&doi=10.1007%2f978-981-16-6415-1_6&partnerID=40&md
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Estimating Erosional and Aggradational Changes in the Riverine Island Majuli using Landsat Data

Kusumbor Bordoloi
Durlov Lahon
Debashree Borah
Krishna Priya Gogoi
Manash Jyoti Nath
Dhrubajyoti Sahariah

Abstract

Majuli, the largest riverine island of the world, and first island district of India located in the Brahmaputra Valley of Assam has been witnessing the unswerving flood and riverbank erosion hazard in last few decades. In this study, an attempt has been made to use Landsat time-series datasets (Landsat 5 TM and Landsat 8 OLI) for the years 1990, 2000, 2010 and 2018 to delineate outline boundary of Majuli island and to quantify erosional/aggradational changes in ArcGIS 10.7 environment. Quantification and identification of erosion/aggradation zones were estimated using 40 numbers of respective square grids (5 km X 5 km) by intersecting them with island boundary polygon for the considered years. Results of this study illustrates that during 28 years of time span (1990 to 2018) 41.18 km2 area was eroded and only 2.85 km2 area aggraded in Majuli island. During the same time span, the land area of Majuli island decreased from 506.31 km2 (1990) to 467.98 km2 (2018), which is a major concern for the identity of the island. On the other hand, high erosion zones were identified within southern part of the island, dominated by the active fluvial processes of the main channel of the Brahmaputra River. Outcome of this research signifies the extreme need of protective and mitigation measures to be taken up for the Majuli island.

Introduction

The Brahmaputra River, counted among world's top ten large anabranching mega-rivers (Lahiri &Sinha, 2014; Latrubesse, 2008), occupying the position of the seventh-largest tropical river in terms ofmean annual discharge (20,000m3/s in Bangladesh) (Lahiri & Sinha, 2014; Latrubesse et al. 2005; Tandon & Sinha, 2008). As a trans-Himalayan river, the Brahmaputra glides through the narrow

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Wetlands of Brahmaputra Floodplain

Dhrubajyoti Sahariah
Kuleswar Sinha

Introduction

The history of humanity has long been linked to river valleys, as has the history of wetlands. The complex connection with wetlands has supplied not only physical resources but has also aided in the development of the human cultural milieu. Many rural economies arose as a result of intricate interactions and significant direct or indirect contributions from wetlands. More crucially, wetlands have produced essential ecosystem services that are necessary for the survival of many plants and animals. Different geo-environmental conditions influence wetland functioning, resources, and qualities.

Due to the complex nature of wetlands, ecologists, agencies, and scientists involved in wetland research struggle to develop a formal regulatory definition of wetlands, and because wetlands have a range of attributes, there is no universally accepted definition of wetlands (Brinson and Malvárez, 2002; Kent, 2000). Wetlands exhibit a wide range of functional attributes and defy a unified functional definition due to their unique size, shape, hydrology, soils, vegetation, and positions in the landscape. Wetlands are transitional habitats because they are neither terrestrial nor aquatic, but have characteristics of both.

Their boundaries are part of a continuum of physical and functional characteristics that may expand or contract over time depending on factors such as average annual precipitation, evapotranspiration, and watershed modifications. Because of the transitional nature of wetlands and the shifting of wetland boundaries, precise identification of wetland boundaries is difficult.

Rural and Urban Settlements

Manash Jyoti Nath

The settlers in North-East India are believed to have occupied this part of land during the Neolithic (8000-3500 B.C) or at the earliest, mid-Palaeolithic times (30,000 years ago). These early settlers are from many racial and linguistic groups that arrived in this part of the region in different time scales.

The first among them to reach is the Mongoloid people who arrived here from the north crossing the Himalayas through the *duars*. Other groups that arrived are Indo-Aryans from Gangetic plains (1000 BC) mainly settled in the Brahmaputra valley, Nagas from highlands of Myanmar (1st millennium AD) settled in Nagaland and Manipur states, followed by the Ahoms (13th century) who settled mainly in the Brahmaputra valley (Figure 14.1). With the advent of the British colonial rules, many other linguistic and religious groups reached this region.

The reason behind all of these migrations to this place is the fertile alluvial soils of river Brahmaputra and the tropical type of climate. The fertile alluvial soil that has been taken care of by the mighty river Brahmaputra year after year, since its origin, means a lot to the settlers. The soil supports greater agricultural productivity and the monsoonal climate has attracted more population to the region. These migrations of people in groups developed a distinctive pattern of settlement and population distribution in relation to the topographic characteristics of the state. The choice and preference of different settlers across communities shaped different types of settlement. The present forms of distribution of settlement both in rural and urban areas have witnessed several historical events and processes.