

Planning Exclusive Maternal Healthcare Facilities Network with Special Reference to India



Thesis submitted towards the partial fulfillment
for the Award of Degree of
Doctor of Philosophy

by

ANKIT CHOUKSEY

under the guidance of

Prof. Anil Kumar Agrawal
Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005

Dr. Ajinkya N. Tanksale
Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005

**DEPARTMENT OF MECHANICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(Banaras Hindu University)
VARANASI – 221 005**

Roll No. 17101502

2022

CERTIFICATE

It is certified that the work contained in the thesis titled "**Planning Exclusive Maternal Healthcare Facilities Network with Special Reference to India**" by Mr Ankit Chouksey (Roll No. 17101502) has been carried out under our supervision and that this work has not been submitted elsewhere for the award of any degree or diploma.

It is further certified that the student has fulfilled all the requirements of Comprehensive Examination, Candidacy, State of Art seminar and Open seminar for the award of Ph.D. Degree.

Supervisor



Prof. Anil Kumar Agrawal

Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005

प्राध्यापक / Professor

यांत्रिक, अभियंत्रिकी विभाग/Deptt. of Mechanical Engg.
भारतीय प्रौद्योगिकी संस्थान/Indian Institute of Technology
(का०हि०वि०/B.H.U.)
वाराणसी-२२१००५/Varanasi-221005

Co-Supervisor



Dr. Ajinkya N. Tanksale

Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005

Assistant Professor

Deptt. of Mechanical Engg.
Indian Institute of Technology (BHU)
Varanasi-221005

DECLARATION BY THE CANDIDATE

I, **Ankit Chouksey**, certify that the work embodied in this thesis is a bonafide research work carried out by me, under the supervision of **Prof. Anil Kumar Agrawal** and **Dr. Ajinkya N. Tanksale** from July 2018 to July **2022**, at the Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi. The matter embodied in this thesis has not been submitted elsewhere for the award of any other degree or diploma. I declare that I have faithfully acknowledged and given credits to the research workers wherever their works have been cited in my work in this thesis. I further declare that I have not will fully copied any other's work, paragraphs, text, data, results, etc. reported in journals, books, magazines, reports dissertations, theses, etc., or available at websites and have not included them in this thesis and have not cited as my own work.

Date: 25/07/2022
Place: IIT (BHU) Varanasi



(Ankit Chouksey)

CERTIFICATE BY THE SUPERVISORS

It is certified that the statement made above by the student is correct to the best of our knowledge.


Supervisor

Co-Supervisor


Prof. Anil Kumar Agrawal
Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005
प्राध्यापक / Professor

यांत्रिक अभियान्तिकी विभाग/Deptt. of Mechanical Engg.
भारतीय प्रौद्योगिकी संस्थान / Indian Institute of Technology
(काठहंडी/वि०/B.H.U.)
वाराणसी-२२१००५ / Varanasi-221005


Dr. Ajinkya N. Tanksale
Mechanical Engineering Department
Indian Institute of Technology (BHU)
VARANASI-221005 Professor
Deptt. of Mechanical Engg.
Indian Institute of Technology (BHU)
Varanasi-221005


Prof. Santosh Kumar
The Head
Department of Mechanical Engineering
IIT (BHU) VARANASI
यांत्रिक अभियान्तिकी विभाग/Deptt. of Mechanical Engg.
भारतीय प्रौद्योगिकी संस्थान / Indian Institute of Technology
(काठहंडी/वि०/B.H.U.)
वाराणसी-२२१००५ / Varanasi-221005

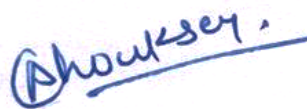
COPYRIGHT TRANSFER CERTIFICATE

Title of the Thesis: Planning Exclusive Maternal Healthcare Facilities Network with Special Reference to India

Name of the Student: Ankit Chouksey

Copyright Transfer

The undersigned hereby assigns to the Indian Institute of Technology (Banaras Hindu University) Varanasi all rights under copyright that may exist in and for the above thesis submitted for the award of the *DOCTOR OF PHILOSOPHY*.



Date: 25/07/2022

Place: IIT (BHU) Varanasi, India

Ankit Chouksey

Note: However, the author may reproduce or authorize others to reproduce material extracted verbatim from the thesis or derivative of the thesis for author's personal use provided that the source and the Institute's copyright notice are indicated.

ACKNOWLEDGEMENTS

Through this page, I offer my salutation to Mahamana Pt. Madan Mohan Malviya Ji, the creator of this pious seat of learning.

It is indeed my proud privilege to express my deep sense of gratitude, respect, indebtedness and sincere regard to my supervisors, Prof. Anil Kumar Agrawal and Dr Ajinkya N. Tanksale, for their excellent supervision, valuable guidance, stimulating discussion, unfailing support, immense help, and constant encouragement over the entire period of my association with them. I am grateful to them for their sincere concern both for academics and personal welfare and parental care throughout the research period, helping me in the successful completion of this research work.

I would like to express my grateful thanks to my Research Progress Evaluation Committee (RPEC) members: Prof. Rajesh Kumar and Prof. Prabhas Bhardwaj, for being kind enough to make the evaluation of my work progress and to offer meaningful comments and fruitful suggestions from time to time.

I wish to acknowledge my sincere gratefulness to Prof. Santosh Kumar, Head, Department of Mechanical Engineering, Indian Institute of Technology (BHU) Varanasi, and also to the former Heads, Prof. A P Harsha and Prof. A K Jha, for their kind gesture and also for extending all sorts of facilities in the department to pursue this research work.

I express my sincere thanks to the office staff and technical staff, especially to Mr Anil Kumar Singh, Mr Rajendra Prasad, Mr Prashant, Mr Akash and Mr anil, who helped me in various ways during this research work. I would like to express my deepest appreciation to the Training and Placement office staff Mr Ghanshyam Gupta, Mr Mohit Shrivastava, Mr Shravan Dubey, Mr Jasawant Lal Roshan and Mr Surendra Kumar, who supported me in many ways throughout this research work.

I express my indebtedness and gratitude to Mrs Bandana Agrawal, the wife of Prof. A K Agrawal and Mrs Poorva Sabnis Tanksale, the wife of Dr. Ajinkya Tanksale, for their affectionate love and all possible support during my research endeavour.

I am highly obliged to express my appreciation towards my seniors, especially Dr Susheel Yadav, Dr Amit Ambar Gupta, Mrs Priya Singh, Mr Meghavatu Krishna Prasanna Naik and Mr Ajeet Yadav, for their affection and support during my research work.

I have been highly blessed with a friendly and cheerful group of fellow research scholars. I want to express my heartfelt gratitude to Ms Munmun for constantly motivating and supporting me throughout my research work. I am extremely grateful to my roommate Mr Adarsh for inspiring and supporting me continuously during my research work. I would like to extend my science thanks, especially to Mr Saurabh, Mr Sumit, Mr Vikram, Mr Abhishek and Mr Mithilesh. They directly or indirectly supported my research work. Their companionship and lively discussions inside and outside the laboratory were a great source of inspiration.

Words plunge insufficient to express my regards and deep emotions toward my beloved parents for being the source of unconditional love and inspiration to move on the way to my goal of achieving higher education. Their everlasting encouragement, patience, sacrifice and blessings have brought me up to this stage. Parents being earthly God, deserve much more than what I can express in words. I would like to offer sincere thanks to my elder brother Mr Harshit Chouksey, and sister-in-law Mrs Sarita Chouksey for their endless support and patience. Words at my command are not sufficient to express my feelings, especially for my sister Ms Priyanshi and my niece Ms Saharsha as their smiling face always rejuvenated me.

I would like to express my gratitude to the Department of Mechanical Engineering, IIT (BHU) Varanasi, for providing me with the necessary facilities for conducting my research work smoothly. I take this occasion to acknowledge the Ministry of Human Resource and Development's financial assistance and Development in the form of Teaching Assistantship.

Finally, I bow my head humbly before the almighty Lord Shiva, without whose blessings this work would have been impossible.

Date: 25/07/2022

Place: Varanasi

Ankit Chouksey

Dedicated
To
My Beloved Mother
in Heaven

TABLE OF CONTENTS

Certificate	ii
Declaration by the candidate	iii
Copyright transfer certificate	iv
Acknowledgements	v
Table of contents	viii
List of figures	xi
List of tables	xiv
List of abbreviations	xvii
Preface	xviii
CHAPTER 1: INTRODUCTION.....	1
1.1 Overview	1
1.2 Challenges in Maternal Healthcare in India	4
1.2.1 Availability and accessibility.....	4
1.2.2 Service quality	6
1.2.3 Population growth.....	6
1.3 Literature Review	7
1.3.1 Facility location problem.....	8
1.3.2 General healthcare facility location.....	9
1.4.4 Maternal healthcare facility location	22
1.4.5 Bibliometric mapping	23
1.4 Research Gaps	27
1.5 Present Work	31
1.5.1 Research scope	31
1.5.2 Research objectives	34
1.6 Organization of the Thesis	35
CHAPTER 2: MATERNAL HEALTHCARE FACILITY PLANNING WITH FULL AVAILABILITY WITHIN REACH.....	37
2.1 Introduction	37
2.2 The Problem	38
2.3 The Mathematical Model	41

2.4 An Illustrative Example	44
2.5 Solution Approaches	52
2.5.1 Valid inequalities	53
2.5.2 Sequential approach.....	56
2.6 Computational Experiments	61
2.6.1 Generation of test instances	61
2.6.2 Experimental results on the suitability of the proposed approaches	63
2.6.3 Experimental results on the efficacy of the proposed valid inequalities	68
2.7 Sensitivity Analysis.....	71
2.7.1 Impact of coverage distance	71
2.7.2 Impact of change in the referral proportion.....	74
2.7.3 Impact of change in the capacity of maternal healthcare facilities.....	76
2.7.4 Impact of change in the fixed cost.....	79
2.8 Conclusions	80
CHAPTER 3: MATERNAL HEALTHCARE FACILITY PLANNING PENALTY ON OVERBURDENING.....	83
3.1 Introduction	83
3.2 The Problem	85
3.3 The Mathematical Model	86
3.4 Metaheuristics Used as Solution Approaches	89
3.4.1 Particle swarm optimization	89
3.4.2 Artificial bee colony algorithm.....	94
3.4.3 JAYA algorithm	100
3.5 Performance Study of the Proposed Metaheuristics	104
3.6.1 Generation of test instances	104
3.6.2 Experimental results and discussion.....	105
3.6.3 Comparative performance analysis of proposed metaheuristics	109
3.5 Impact of change in demand and penalty.....	111
3.6 Hybrid Optimization-Simulation Framework with Normally Varying Demand	114
3.6.1 Optimization phase.....	114
3.6.2 Simulation phase.....	115
3.6.3 Simulation for example problem	119
3.6.4 Simulation on randomly generated problems.....	121

3.4.5 Observations	125
3.7 Conclusions	126
CHAPTER 4: MULTI-PERIOD MATERNAL HEALTHCARE FACILITY PLANNING CONSIDERING POPULATION GROWTH	129
4.1 Introduction	129
4.2 The Problem	130
4.3 Model Formulation.....	132
4.4 Solution Approaches	139
4.5 Benders decomposition	140
4.5.1 Classical Benders decomposition	144
4.5.2 Accelerated Benders decomposition	146
4.5.3 Benders type heuristic	154
4.6 Particle Swarm Optimization	156
4.7 Hybridized Simulated Annealing	164
4.7.1 Set covering problem.....	165
4.7.2 Fix-and-optimize	166
4.7.3 Implementation of Simulated annealing.....	168
4.8 Computational Experiments.....	173
4.8.1 Generation of test instances	173
4.8.2 Experimental results	176
4.9 Integrated vs Disaggregated Planning.....	193
4.10 Case example.....	200
4.11 Conclusions	204
CHAPTER 5: CONCLUSIONS AND SCOPE FOR FURTHER WORK	207
5.1 Conclusions	207
5.2 Managerial Implications of the Study	211
5.3 Scope for Future Research	212
REFERENCES.....	213
APPENDIX-A.....	237
LIST OF PUBLICATIONS	241
BIBLIOGRAPHY	243

LIST OF FIGURES

Figure 1.1: Cases related to accessibility issues of healthcare facilities in rural areas	5
Figure 1.2: Demographic projection of India in 2036	7
Figure 1.3: Network visualization for minimum co-occurrence as 20	25
Figure 1.4: Network visualization for minimum co-occurrence as 5	26
Figure 1.5: Undertaken research problem framework related to planning of maternal healthcare system in India	32
Figure 2.1: Allocation of Mothers-to-be in a different types of facilities.....	43
Figure 2.2 : Locations of mothers-to-be	45
Figure 2.3: Location solution for healthcare facilities to be established	49
Figure 2.4: Allocation of mothers-to-be to various facilities for service types 1 and 2	50
Figure 2.5: Allocation of mothers-to-be for service type 3	50
Figure 2.6: Pseudo-code for the construction stage of sequential approach.....	58
Figure 2.7: Pseudo-code for the improvement stage of the sequential approach	59
Figure 2.8: Pseudo-code for the refinement stage of the sequential approach	60
Figure 2.9: Increase in (a) total number of variables (b) number of establishment variables	63
Figure 2.10: Effect on the overall cost due to variation in maximum coverage distance (a) a non-referral visit and (b) for a referral visit	73
Figure 2.11: Effect of maximum coverage distance for non-referral visits.....	73
Figure 3.1: Framework of proposed PSO	94
Figure 3.2: Framework for implementation of ABC algorithm.....	99
Figure 3.3: Framework for the proposed JAYA algorithm.....	103

Figure 3.4: Various problem classes	105
Figure 3.5: Optimization and simulation framework.....	118
Figure 3.6: Effect of the capacity on overall traveling cost for the example problem	120
Figure 3.7:Effect of COV on the service level of BU's for the example problem	120
Figure 3.8: Variation in service level with the length of simulation run for COV as 0.5 for the problem class D10, D20, D50 and D100	122
Figure 3.9: Service level vs COV for the problem instances (a) D10 (b) D20 (c) D50 (d) D100	125
Figure 4.1: Allocation of mothers-to-be to different types of facility	139
Figure 4.2: Framework of classical Benders decomposition.....	145
Figure 4.3: Framework for implementation of parallelism to solve DSP.....	152
Figure 4.4: Framework for accelerated Benders decomposition algorithm.....	153
Figure 4.5: Pseudo-code for proposed Benders type heuristic	156
Figure 4.6: Flowchart showing binary PSO implementation.....	159
Figure 4.7: Steps for generation of random initial solution.....	163
Figure 4.8: Pseudo-code for local search.....	164
Figure 4.9: Pseudo-code for fix-and-optimize	167
Figure 4.10: Flowchart of proposed simulated annealing framework	171
Figure 4.11: Framework for the generation of neighbourhood solutions	172
Figure 4.12: Various problem sizes	176
Figure 4.13: Optimality gap obtained for (a) small, (b) medium and (c) large size problem instances.....	187
Figure 4.14: Convergence of a problem of 50 nodes 5 time period and 2 nd instance.....	189

Figure 4.15: Comparison of UB obtained for (a) small, (b) medium (c) large size problem instances 191

Figure 4.16: Locations of the different types of existing facilities 201

Figure 4.17: Locations of the different types of facilities 204

LIST OF TABLES

Table 1.1: Summary of the research papers related to locating healthcare facilities based on the modeling approach.....	13
Table 1.2: Summary of research papers related to the type of healthcare facilities	14
Table 1.3: Summary of the research work related to capacity consideration	15
Table 1.4: Summary of the research work related to coverage distance consideration.....	16
Table 1.5: Summary of the research work related to referral consideration.....	16
Table 1.6: Summary of the papers related to various types of costs.....	17
Table 1.7: Summary of the research work based on time-period consideration.....	20
Table 1.8: Summary of research work based on the approaches applied to solve HFLPs	21
Table 1.9: Number of research articles found in the Scopus database	24
Table 1.10: Summarized literature review	29
Table 2.1: Number of MTBs at various locations.....	46
Table 2.2: Referral proportion and assumed capacity for the illustrative example	46
Table 2.3: Distance Matrix (distances in km).....	47
Table 2.4: Location of facilities	49
Table 2.5: Non-referral allocations of mothers-to-be	51
Table 2.6: Referrals allocations mothers-to-be	51
Table 2.7: Capacity (units) of the facilities.....	62
Table 2.8: Optimal solutions obtained by HCFL and VI-HCFL approaches for some problems	66
Table 2.9: Problems in which the same UB is obtained by HCFL and VI-HCFL formulations ..	66
Table 2.10: Results for other problem instances.....	67
Table 2.11: Comparison of HCFL formulation with valid inequalities.....	70

Table 2.12: Results of Wilcoxon signed-rank test	71
Table 2.13: Effect of change in the referral proportion	75
Table 2.14: Effect of variation in the capacity of various service types in CHC	77
Table 2.15: Effect of variation in the capacity of various service types in PHC	78
Table 2.16: Effect of variation in the capacity of various service types in SC	79
Table 2.17: Effect of variation in fixed cost	80
Table 3.1: Experimental results of proposed solution approaches	106
Table 3.2: Wilcoxon-signed rank test for solution quality	110
Table 3.3: Wilcoxon-signed rank test for CPU time.....	110
Table 3.4: Impact of change in demand and penalty	112
Table 3.5: Summary of computational experiments	124
Table 4.1: Steps for relax-and-fix	155
Table 4.2: Various problem sizes.....	175
Table 4.3: Values of problem parameters used in computational experiments	175
Table 4.4: Computational results for 5-time period.....	178
Table 4.5: Computational results for 5-time period.....	179
Table 4.6: Computational results for 10-time period.....	180
Table 4.7: Computational results for 10-time period.....	181
Table 4.8: Computational results for 15-time period.....	182
Table 4.9: Computational results for 15-time period.....	183
Table 4.10: Computational results for 20-time period.....	184
Table 4.11: Computational results for 20-time period.....	185
Table 4.12: Solution of MHCFL formulation for 5-time period	195

Table 4.13: Solution of sequential approach for 5-time period	195
Table 4.14: Solution of MHCFL formulation for 10-time period	195
Table 4.15: Solution of sequential approach for 10-time period	196
Table 4.16: Solution of MHCFL formulation for 15-time period	196
Table 4.17: Solution of sequential approach for 15-time period	197
Table 4.18: Solution of MHCFL formulation for 20-time period	197
Table 4.19: Solution of sequential approach for 20-time period	198
Table 4.20: Solution of sequential approach for 20-time period with very high penalty	199
Table 4.21: Comparison of the objective value of MHCFL formulation and sequential approach	199
Table 4.22: Problem parameters used in the case problem.....	202
Table 4.23: Objective function value obtained from proposed solution approaches.....	203
Table 4.24: Number of different types of facilities required	203

LIST OF ABBREVIATIONS

ABC	Artificial Bee Colony Algorithm
BD	Benders Decomposition
CHC	Community Healthcare Center
DSP	Dual Sub-Problem
FLP	Facility Location Problem
HCFL	Hierarchical Capacitated Facility Location
HFLP	Healthcare Facility Location Problem
LB	Lower Bound
MHCFL	Multi-period Hierarchical Facility Location Problem
MILP	Mixed-Integer Linear Programming
MMR	Maternal Mortality Ratio
MP	Master Problem
MTB	Mother-to-be
PHC	Primary Healthcare Center
PSO	Particle Swarm Optimization
SA	Simulated Annealing
SC	Sub-Center
SP	Sub Problem
UB	Upper Bound
VI	Valid Inequalities

PREFACE

The present work seeks to establish a structured approach for proper planning of the maternal healthcare facilities to address the availability and accessibility issues that mothers-to-be (MTBs) had to face mostly in developing and underdeveloped countries. These issues also concern India. The Indian Government has been moving its resources for better maternal healthcare through its schemes, such as, Janani Suraksha Yojana–2005, National Rural Health Mission–2005, Pradhan Mantri Surakshit Matritva Abhiyan–2016, etc.

Planning for the required maternal healthcare facilities, from basic ones to neonatal ones, while considering population growth is a tedious task for the Governments. In the present work, this planning problem has been addressed by proposing several mixed-integer linear programming (MILP) formulations for determining the optimal number and locations of varied and capacitated maternal healthcare facilities for different planning scenarios. These formulations also help in optimal allocation of MTBs to these facilities while minimizing the overall cost. The facilities are hierarchical (i.e., a system of different types of interacting facilities) and successively inclusive (i.e., a higher level will also provide all lower-level services). All these models are equally applicable in the Indian context.

In the first variation, the planning framework does not compromise on service quality. Considering accessibility issues in terms of coverage distance and availability issues in terms of establishing required facility types, the mathematical model has been developed. The proposed model is NP-hard and is thus computationally inefficient in solving the planning problem. To reduce the computational time requirement, three additional valid inequalities are proposed. Computational experiments and statistical test confirm the usefulness of these valid inequalities. Additionally, a sequential approach is also proposed to cut down the computational requirements sizably without

practically compromising the solution quality. Sensitivity analyses have been carried out with respect to coverage distance, capacity, referral proportion and fixed cost to provide important and practical insights related to the mix of the facilities to be established.

The healthcare facilities are generally overburdened due to large demand in excess of capacity of the facilities and is mainly because of lack of funds for creating the right number and mix of facilities. Under such a scenario, overburdening may be unavoidable but is certainly undesirable. To acknowledge this practical reality, the earlier proposed planning framework was modified to accommodate the possibility of overburdening but at a penalty cost. The level of penalty cost controls the amount of overburdening and the number of maternal healthcare facilities to be established. The small penalty cost causes huge overburdening but establishment of a few facilities. A very high penalty has the opposite effect. The amount of overburdening in comparison to the capacity of the facilities defining the service quality is naturally is the best in the case of high penalty costs. Understandably, the mathematical model encompassing the features of this planning problem is also NP-hard. For solving the large-size real-world problem in a reasonable time, suitable frameworks of Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), and JAYA metaheuristics have been developed. Extensive computational experiments have been performed to analyze their comparative efficiency and usefulness. PSO was found to be the best. The proposed mathematical model assumed the demand for various maternal healthcare services to be deterministic. In real life, the demand for these services may vary day-to-day and these variations may be random. For this reason, the robustness of the solutions for deterministic demand case has been analysed for application in stochastic demand case by performing computational experiments on several problems of varying size and variability in the demand. It was found that

the solutions obtained are practically quite robust. The sensitivity strengthened our belief in increasing the penalty cost for achieving high service quality.

The maternal healthcare planning frameworks presented above, and also in the available literature, did not address the multiperiod maternal healthcare planning problem. Simultaneous planning over the whole planning horizon, as compared to period-wise planning, results in a better plan for establishing and upgrading the facilities in various periods of the planning horizon. The upgradation of healthcare facilities is a common phenomenon and has been encountered, at least in the Indian context. This aspect considered in the present research work has not been viewed by any other researcher so far, at least for the planning of maternal healthcare facilities. Besides, the planning framework considers the possibility of referrals from all the lower level facilities to their higher level facilities. This generalized feature of referral, which is practically common in India, has not been considered in the available researches. The framework of the mathematical model is general. One has to simply change the number of periods in the planning horizon to comp up with mid-term planning or long-term planning decisions. Incorporating all these realities of the planning framework, the proposed mathematical model proposed also considers inflationary pressure on the cost parameters and growth in the demand of services from MTBs owing to population growth. To solve the developed multi-period planning problem effectively and efficiently, an accelerated Benders Decomposition algorithm (a Benders Decomposition Algorithm with several acceleration strategies such as valid inequalities, disaggregated Benders cuts, rolling horizon heuristic and parallelism) has been developed. A Benders type heuristic is also tested by solving the master problem heuristically. Additionally, Particle Swarm Optimization (PSO) with local search and hybridized Simulated Annealing (SA) approaches have also been developed to obtain good quality solutions in a reasonable time, particularly for large-size planning problems. The results of the

computational experiments find the accelerated Benders Decomposition algorithm and Benders-type heuristic to outperform the Gurobi solver for medium and large-size problems in terms of solution quality. The proposed PSO heuristic performed worst, whereas hybrid SA was found to be the best in yielding better solutions in lesser CPU time. Computational experiments prove the premise of integrated planning being economically better than year-to-year based planning.

The application of the proposed models has been demonstrated by taking the problem of maternal healthcare planning for a region in India. The case study shows a lot of work to be done to significantly improve the existing maternal healthcare infrastructure in order to meet the Strategic Development Goals (SDGs).

