

Table of Contents

List of Figures	X
List of Tables	XII
List of Abbreviations.....	XIII
List of Symbols.....	XIV
1 Introduction	1
2 Wood Resources and their Potential Cascade Uses.....	7
2.1 Wood and its application.....	7
2.2 Forest sources in Germany.....	8
2.3 Wood flow and its proportion in different sectors.....	11
2.3.1 Waste wood and waste paper utilization	14
2.3.1.1 Waste wood classification	14
2.3.1.2 Mechanical disintegration.....	16
2.3.1.3 Thermo-hydrolytic disintegration.....	17
2.3.2 Recycling of wood-based products.....	22
2.3.2.1 Medium density fiber (MDF).....	24
2.3.2.1 Particle wood.....	26
2.3.2.2 Oriented strand board (OSB).....	31
2.3.2.3 Pulp and paper production and recycling.....	33
2.3.2.4 Wood pellets and energy use of wood.....	40
2.4 Summary.....	43
3 Modeling of the Logistics Network for Wood Utilization in Cascade versus Utilization of Fresh Wood.....	45
3.1 Cascade utilization.....	45
3.2 Logistics network for wood flow	51
3.2.1 Supply processes for wood resources.....	51
3.2.1.1 Harvest.....	51
3.2.1.2 Storage.....	53
3.2.1.3 Sawmill industry	54
3.2.1.4 Handling	55
3.2.1.5 Transport.....	55
3.2.2 Application of operations research for optimizing the logistics network for wood flow.....	56
3.3 Summary.....	60
4 Mathematical and Environmental Modeling of a Wood Logistics Network	61
4.1 Development of the optimization model.....	61

4.1.1	Value chain for wood products	61
4.1.2	Modelling of the Logistics network for wood products	62
4.1.3	Nomenclature.....	65
4.1.3.1	Sets	65
4.1.3.2	Parameters.....	65
4.1.3.3	Decision variables	66
4.1.3.4	Variables	66
4.2	Network description	67
4.3	Mathematical model.....	68
4.3.1	Objective function	68
4.3.2	Constraints	69
4.4	Logistics network – specific equations.....	70
4.4.1	MDF	70
4.4.2	OSB	71
4.4.3	Particleboard.....	71
4.4.4	Pulp and paper.....	71
4.4.5	Wood pellets	71
4.4.6	Transportation.....	72
4.5	Life cycle assessment (LCA)	72
4.6	Implementation of the optimization model	77
4.7	Summary.....	77
5	Sustainable Logistics Network for Wood Flow Considering Cascade Utilization (Case Study 1)	79
5.1	Scenarios for the logistics network	83
5.1.1	Scenario 1: logistics network for the wood flow of six companies in Lower Saxony from fresh wood	83
5.1.2	Scenario 2 and 3: logistics network for wood flow from cascade utilization	84
5.2	Results of case study 1	85
5.3	Sensitivity analysis of the global warming potential of the logistics processes	89
5.4	Summary.....	92
6	Utilization of Wood Resources in a Logistics Network for Wood Products Taking Economic and Environmental Parameters into Account (Case Study 2).....	93
6.1	Multi-objective optimization of the logistics network for wood products	93
6.2	Development of a Bi-Objective Model	96
6.2.1	Nomenclature.....	97
	Parameters	97
6.2.2	Objective function	98
6.2.3	Constraints.....	100
6.3	Data sources	101

6.4	Implementation of a bi-objective optimization of the logistics network for wood flow from cascade utilization	105
6.5	LCA result of the logistics network for wood flow	107
6.5.1	Scenarios for the logistics network for wood flow	107
6.5.2	Impact categories	109
6.5.3	Global warming potential (GWP)	111
6.5.4	Other environmental impact categories	112
7	Conclusion and Outlook for Further Work	119
7.1	Conclusion	119
7.2	Outlook on further research	122
8	Summary	125
	References	127
	Appendix	147