Contents

Acknowledgment 3
Extended Summary 11
Introduction 13
1. Basic Characteristics of the Area **15**
1.1 Location and Accessibility 15
1.2 Population, Settlements and Health Status 16
1.3 Land Use 23
2. Selected Physical and Geographical Settings **25**
2.1 Geomorphology 25
2.2 Soil and Vegetation Cover 26
2.3 Climatic Characteristics 29
2.3.1 Climatic Zones and Measurements 29
2.3.2 Precipitation 31
2.3.3 Other Climatic Characteristic 37
2.4. Hydrography and Hydrology of the Area 39
2.4.1 Surface Water Network Development 39
2.4.2 Surface Water Regime 43
2.4.3 Baseflow 45
2.5 Drought and Climate Changes 49
3. Geological Settings **55**
3.1 Previous Work 55
3.2 Stratigraphy 55
3.3 Lithology 56
3.3.1 Precambrian Crystalline Formations 56
3.3.2 Mesozoic Sedimentary Formations 57
3.3.2.1 Adigrat - The Lower Sandstone (Tas) 57
3.3.2.2 Hamanlei Formation (Jhl) 58
3.3.2.3 Amba Aradom - The Upper Sandstone (Ka) 58
3.3.3 Tertiary and Quaternary Basalts 59
3.3.4 Quaternary Covers 60
3.4 Structure 60
3.5 Geological History 61
4. Hydrogeology **63**
4.1 Water Point Inventory 63
4.2 Hydrogeological Classification/Characterization 65
4.3 Elements of the Hydrogeological System of the Area (Aquifers and Aquitards) 66
4.3.1 Extensive and Moderately Productive Porous Aquifers 67
4.3.2 Extensive and Highly Productive Fissured and Karstic Aquifers 69
4.3.3 Extensive and Moderately Productive Fissured Aquifers 72
4.3.4 Extensive and Low Productive Fissured Aquifers 74
4.3.5 Aquitards and/or Minor Aquifers with Local and Limited Groundwater Resources 78
4.4. Hydrogeological Conceptual Model 78
4.5 Annual Recharge in the Area 80
5. Hydrogeochemistry **83**

5.1 Sampling and Analysis 83
5.2 Classification of Natural Waters 85
5.2.1 Rain Water 88
5.2.2 Surface Water 88
5.2.3 Groundwater in Volcanic Rocks 88
5.2.4 Groundwater in Mesozoic Sediments 89
5.2.5 Groundwater in Quaternary Sediments 89
5.2.6 Groundwater in Basement Rocks 90
5.3 Water Quality 90
5.3.1 Domestic Use 90
5.3.2 Irrigation Use 92
5.3.3 Industrial Use 92
5.4 Mineral and Thermal Water 94
6. Natural Resources of the Area 95
6.1 Economic Geology 95
6.2 Water Resources 95
6.2.1 Surface Water Resources Development 97
6.2.2 Groundwater Resources Development 98
6.3 Human and Land Use Resources and Development 102
6.4 Wind and Solar Energy Development 102
6.5 Environmental Problems and their Control / Management 102
6.6 Touristic Potential of the Area 106
Conclusions 107
References 109
Annex 1 – Field Inventory Data 111
Annex 2 – Water Chemistry 121
Annex 3 – Well Logs 127