Reorganization and Risk: Environmental Change and Tribal Land Use in

Marginal Landscapes of Southern Jordan

by

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ABSTRACT

This research on the early metal ages of the Wadi el-Hasa focuses on the settlement systems and attempts to explain how social, economic and political adjustments helped tribal groups survive under natural (i.e., climatic) and anthropogenic (i.e., land degradation, erosion) stress factors. The shifting of subsistence base from agropastoral to pastoral their reflections in site and population densities, diversity of site types, levels of internal complexity and levels of social organization via the presence of large settlements, like villages, which acted as economic and administrative centers emerge as risk reduction mechanisms. The cycles of abandonment and resettlement are evaluated within the concept of social reorganization and such changes are assessed as parts of economic revitalization attempts. The social changes that emerge from such shifts are evaluated from the perspective of the scale-free networks model and tested through statistical methods, such as ANOVA, for spatial and temporal patterns while patterns of land use and the impacts of changing climate and anthropogenic activities are evaluated with GIS. Following the dimorphic society and heterarchic social organization concepts, the discussion emphasizes that tribal groups adjust population density, range and intensity of activities in marginal landscapes, like the Hasa, in order to prevent environmental degradation. These patterns may change once these marginal landscapes are integrated to more complex social organizations. Although this takes place in the Hasa during the Iron Age, the research results imply that environmental degradation did not take place possibly due to the continuation of extensive subsistence patterns, along with the emergence of the long-distance caravan trade as a major economic incentive.

DEDICATION

"I am not leaving a spiritual legacy of dogmas, unchangeable petrified directives. My spiritual legacy is science and reason."

Mustafa Kemal Atatürk The Founder of the Republic of Turkey (1881-1938)

"... This great Nation will endure as it has endured, will revive and will prosper. So, first of all, let me assert my firm belief that the only thing we have to fear is fear itself – nameless, unreasoning, unjustified terror which paralyzes needed efforts to convert retreat into advance."

Franklin Delano Roosevelt The Thirty-second President of the United States of America (1882-1945)

To my grandparents, whose life-long dedication to education sharpened my curiosity and kept me inquiring. Without their early guidance and spiritual support, none of this would have come true.

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TABLE OF CONTENTS

| IST OF TABLES |
|---|
| IST OF FIGURESxiii |
| CHAPTER |
| 1 INTRODUCTION |
| Research Goals 1 |
| Intellectual Context |
| Research Questions |
| Theoretical Approaches |
| Research Area7 |
| Overview of Research Methods and Data |
| Organization of the Dissertation |
| Broader Impacts |
| 2 THE THEORY OF ABANDONMENT AND RESETTLEMENT 16 |
| Introduction |
| Overview |
| Abandonment19 |
| Social Change |
| Remote and Local Decision Making |
| The Hasa Synthesis |

CHAPTER

| 3 | THE HISTORY OF ARCHAEOLOGICAL AND | |
|---|---|-------|
| | PALEOENVIRONMENTAL RESEARCH IN THE LEVANT AND | |
| | TRANSJORDAN | 44 |
| | The Geographic Locations | 44 |
| | The Paleolithic Prehistory in the Levant and Transjordanian Plateau | 44 |
| | The Holocene Prehistory and Early History in the Levant and | |
| | Transjordanian Plateau | 45 |
| | The Archaeological Research | 54 |
| | Paleoenvironmental Research | 59 |
| | Overview | 74 |
| 4 | RESEARCH QUESTIONS AND METHODS | 76 |
| | Introduction | 76 |
| | Data | 78 |
| | Estimating Site Size and Function | 79 |
| | Research Questions | 81 |
| | Analytical Methods | . 107 |
| | Description of Analytical Methods Used for Answering the Research | |
| | Questions | . 110 |
| 5 | THE TEMPORAL PATTERNS OF CHANGE IN THE SETTLEMENT | |
| | SYSTEMS AND IN THE ENVIRONMENT OF THE HASA | 122 |
| | Introduction | . 122 |

| CHAPTER | | Page |
|----------|--|------------|
| 5 | The General Characteristics of the Hasa Settlements | 123 |
| | The Overview of the Hasa Topography | 139 |
| | Tracking Environmental Change through Precipitation and Temp | erature in |
| | the Hasa Drainage | 185 |
| | Site Distribution Characteristics | |
| 6 | SOCIAL FACTORS OF CHANGE AND HUMAN RESPONSES | 214 |
| | Introduction | 214 |
| | Cooperation and Conflict throughout the Early Metal Ages | 214 |
| | The Peripheralization of the Hasa During the Iron Age | |
| | Temporal Changes in Site Size and Social Organization | 247 |
| | Landscape Evolution | |
| | Human Impacts | 257 |
| | New Settlements and Resiliency | 278 |
| 7 | CONCLUSION | 286 |
| | Introduction | |
| | The Hasa Synthesis | |
| | The Fit Between Research results and the Hasa Synthesis | |
| | Landscape Evolution and Human Impacts | |
| | Hasa Synthesis in the Regional Context | 299 |
| | Broader Impacts | 305 |
| REFERENC | CES | 307 |

LIST OF TABLES

| Table | Page |
|-------|---|
| 1. | The comparative population coefficients used by Gophna and Broshi |
| | (1986) and Broshi (1993) |
| 2. | The population estimates for the Galilee-Judea region by Gophna and |
| | Broshi (1986) 84 |
| 3. | Hasa sites that are digitally mapped and used as basis for verifying site |
| | functions |
| 4. | The population estimates for the Hasa |
| 5. | The summary table for the demographic characteristics of the Hasa |
| | population based on population density, settlement patterns and site |
| | complexity |
| 6. | The classification of the Hasa site types into general groups 125 |
| 7. | The color, range of degree, description, cell count, area and percentage |
| | each slope category in the Hasa |
| 8. | The settlement density and the percentage of area occupied for each slope |
| | category in the Hasa |
| 9. | The summary table showing the most common slope category in each |
| | period, the slope preferences of each site type in each period and |
| | associated site densities |
| 10. | The color, description, cell count, area and percentage cover of each |
| | landform category in the Hasa based on Figure 30 155 |

Table

| 11. | The settlement density and the percentage of area occupied on each | |
|-----|---|-----|
| | terrain type in the Hasa | 157 |
| 12. | The summary table showing the most common landforms in each period | |
| | and the landform preferences along with respective site density of each | |
| | site type in each period | 165 |
| 13. | The changes in settlement density and the percentage of the Hasa under | |
| | human activity during the early metal ages | 174 |
| 14. | The summary table showing mean, median and CV values for | |
| | precipitation from the Chalcolithic to the Iron Age | 190 |
| 15. | The summary table showing mean, median and CV values for | |
| | temperature from the Chalcolithic to the Iron Age | 193 |
| 16. | The summary table showing environmental variables, predominant site | |
| | types and complexity patterns according to periods and modes in | |
| | elevation | 208 |
| 17. | The temporal density of military sites in the Hasa throughout the early | |
| | metal ages | 216 |
| 18. | The comparison table for temporal changes in densities of military and | |
| | other site types. | 218 |
| 19. | The density of military sites according to landform categories | 220 |
| 20. | The summary table comparing median precipitation values for villages | |
| | and other sites in the EB I-III and IA | 241 |

Table

| 21. | The summary table showing the climatic and environmental variables | |
|-----|--|-----|
| | used for landscape evolution modeling in the Hasa | 253 |
| 22. | The summary table showing the statistical results of landscape evolution | |
| | models by period | 256 |
| 23. | The summary table showing the number of habitation units, estimated | |
| | population, coefficient for population and site size for each site used in | |
| | modeling | 259 |
| 24. | The summary table showing the sizes of agricultural and pastoral | |
| | catchments for each site used in modeling | 259 |
| 25. | The number of total, new and continuing sites in each period | 279 |
| 26. | The summary table for the characteristics of anew and continuing | |
| | settlements between EB I-III and IA | 280 |

LIST OF FIGURES

| Figure | Pa | ıge |
|--------|--|-----|
| 1. | The Wadi el-Hasa as seen in ASTER imagery | . 2 |
| 2. | The site of WHS-23 El-Mashmil in the west Hasa with archaeological | |
| | and natural features mapped on ASTER imagery and pointed by arrows | 10 |
| 3. | An example of the power law distribution where nodes are ranked | |
| | according to the number relationships they have | 31 |
| 4. | The site of WHS-23 El-Mashmil in the west Hasa with archaeological and | |
| | natural features mapped on ASTER imagery and pointed by arrows | 86 |
| 5. | Temporal distribution of the Hasa sites between Chalcolithic and the Iron | |
| | ages 1 | 23 |
| 6. | The line chart showing the changes in density of settlements and their | |
| | percentages after the settlement frequency is scaled by unit time 1 | 24 |
| 7. | The number and percentage of sites in categories described in Table 7 1 | 26 |
| 8. | The temporal distribution of site categories mentioned in Table 6 1 | 27 |
| 9. | The Chalcolithic period distribution of all site types on landforms (a); and | |
| | the frequency of different site types on level terrains (b), ridges (c), | |
| | saddles (d) and valleys (e) 1 | 28 |
| 10. | The EB I-III period distribution of all site types on landforms (a); and the | |
| | frequency of different site types on level terrains (b), ridges (c), saddles | |
| | (d) and valleys (e) 1 | 29 |

11.

12.

13.

14.

15.

16.

17.

18.

| The EB IV-LB period distribution of all site types on landforms (a); and | |
|--|-----|
| the frequency of different site types on level terrains (b), ridges (c), and | |
| valleys (d) | 130 |
| The IA period distribution of all site types on landforms (a); and the | |
| frequency of different site types on level terrains (b), ridges (c), saddles | |
| (d) and valleys (e) | 132 |
| The ANOVA chart showing the temporal patterns of change in the | |
| number of calculated features at sites | 134 |
| 10-meter resolution digital elevation map (DEM) of the Hasa draped over | |
| shaded relief map, showing the Chalcolithic settlements | 135 |
| 10-meter resolution digital elevation map (DEM) of the Hasa draped over | |
| shaded relief map, showing the EB I-III settlements | 136 |
| 10-meter resolution digital elevation map (DEM) of the Hasa draped over | |
| shaded relief map, showing the EB IV-LB settlements | 137 |
| 10-meter resolution digital elevation map (DEM) of the Hasa draped over | |
| shaded relief map, showing the IA settlements | 138 |
| The slope map of the Hasa draped over shaded relief map. The legend | |
| shows colors of the slope categories described in Table 8 | 140 |

19. The number and percentage of sites in each slope category 142

Page

| 20. | The bar chart showing the site density on slope categories from Figure | |
|-----|---|-----|
| | 19 and Table 8 | 143 |
| 21. | The distribution of all sites on medium slopes according to period (a), | |
| | site types (b), elevation (c), and the number of calculated features (d) | 145 |
| 22. | The distribution of all sites on medium steep slopes according to period | |
| | (a), site types (b), elevation (c), and the number of calculated features (d) | 146 |
| 23. | The distribution of all sites on steep slopes according to period (a), site | |
| | types (b), elevation (c), and the number of calculated features (d) | 147 |
| 24. | The bivariate analysis ($R^2 = 0.86$) indicates relationship between slope | |
| | category and mean site size | 149 |
| 25. | The bar chart showing site densities on the predominant slope category | |
| | (i.e., flat) between the Chalcolithic and the Iron Age | 150 |
| 26. | The distribution of all small economic sites in each period | 152 |
| 27. | The distribution of all activity-facility sites in each period. | 153 |
| 28. | The distribution of all military sites in each period | 154 |
| 29. | The distribution of all large economic sites in each period | 154 |
| 30. | 'r.param.scale' map of the Hasa (moving window size 33 cells) showing | |
| | the categories of terrain (10-meter resolution) | 155 |
| 31. | The number and percentage of the Hasa sites in each landform category | 156 |
| 32. | The bar chart showing the site density on landform categories from | |
| | Figure 31 and Table 11 | 158 |
| | | |

| 33. | The distribution of all sites on level terrain according to period (a), site |
|-----|---|
| | types (b), elevation (c), and the number of calculated features (d) 159 |
| 34. | The distribution of all sites in valleys according to period (a), site types |
| | (b), elevation (c), and the number of calculated features (d) 160 |
| 35. | The distribution of all sites on saddles according to period (a), site types |
| | (b), elevation (c), and the number of calculated features (d) 161 |
| 36. | The distribution of all sites on ridges according to period (a), site types |
| | (b), elevation (c), and the number of calculated features (d) 163 |
| 37. | The distribution of all sites on peaks according to period (a), site types |
| | (b), elevation (c), and the number of calculated features (d)164 |
| 38. | The bar chart showing site densities on the predominant landforms (i.e., |
| | valleys and ridges) between the Chalcolithic and the Iron Age 167 |
| 39. | The bar chart comparison of median precipitation values in each period |
| | based on the landforms described in Table 10 168 |
| 40. | The distribution of all small economic sites according to landforms in |
| | Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d) 169 |
| 41. | The distribution of all activity-facility sites according to landforms in |
| | Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d) 170 |
| 42. | The distribution of all military sites according to landforms in |
| | Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d) 171 |
| 43. | The distribution of all large economic sites in the EB I-III (a) and IA (b) 172 |

| 44. | 'r.prominence' map of the Hasa drainage at .5 km radius (10 meter |
|-----|--|
| | resolution. The black arrows show the prominent locations in the area) 172 |
| 45. | The detail of the Figure 44: zoomed into the west Hasa, around As-Safi. 173 |
| 46. | The bar chart showing the length of each time period and the changes in |
| | number of sites throughout the periods 174 |
| 47. | The Hasa Basin |
| 48. | The individual watersheds in the Hasa with sites used in this research 177 |
| 49. | The number and percentage of sites in watersheds, shown in Figure 48 177 |
| 50. | The most heavily settled watersheds in the Hasa 178 |
| 51. | The distribution of sites from Basin 18. Temporal distribution (a), site |
| | type distribution (b), elevation range (c), the level of site complexity (d) |
| | and terrain categories (e) 179 |
| 52. | The ANOVA chart showing temporal changes in the rates of water |
| | accumulation |
| 53. | The ANOVA chart showing temporal changes in the distance of sites to |
| | water sources |
| 54. | The map of the weather stations around the Hasa, which are used for the |
| | Macrophysical Climate Modeling 186 |

| 55. | The precipitation landscape map of the southern Jordan for 1000 BP, |
|-----|--|
| | including the Hasa (shown as 50-meter contour map) and the early metal |
| | age sites |
| 56. | The weather stations around the Hasa and the average precipitation |
| | values (milimeters) from the early metal ages |
| 57. | The distribution of average precipitation values in the Chalcolithic, |
| | EB I-III, EB IV-LB and IA |
| 58. | The distribution of average temperature values (Celsius) in the |
| | Chalcolithic, EB I-III, EB IV-LB and IA192 |
| 59 | The ANOVA chart for EB I-III precipitation variation according to site |
| | categories |
| 60. | The ANOVA chart for EB IV-LB precipitation variation according to site |
| | categories |
| 61. | The ANOVA chart for IA precipitation variation according to site |
| | categories |
| 62. | The ANOVA chart for EB I-III temperature variation according to site |
| | categories |
| 63. | The ANOVA chart for IA temperature variation according to site |
| | categories |
| 64. | The ANOVA chart for EB I-III precipitation variation according to internal |
| | complexity of sites |

Page

| 65. | The ANOVA chart for Chalcolithic temperature variation according to | |
|-----|--|-----|
| | internal complexity of sites. | 200 |
| 66 | The ANOVA chart for EB I-III precipitation variation according to | |
| | landforms | 201 |
| 67. | The ANOVA chart for EB IV-LB precipitation variation according to | |
| | landforms | 202 |
| 68. | The ANOVA chart for IA precipitation variation according to landforms | 203 |
| 69. | The histogram and the statistics table for the elevation distribution of all | |
| | Hasa sites | 205 |
| 70. | The ANOVA chart of the elevation of sites by time period in the Hasa | 206 |
| 71. | The thematic map of the military sites in the Hasa in relation with the stre | am |
| | network in the drainage | 215 |
| 72. | The stacked bar chart for towers and forts from each period (y-axis) | 216 |
| 73. | The graphical comparison of the data presented in Table 18 | 218 |
| 74. | The landform distribution of the IA towers (n=14) | 220 |
| 75. | The ANOVA chart of the military sites (forts and towers combined) for | |
| | the changes in level of internal complexity. | 221 |
| 76. | The map of the Chalcolithic military sites (blue crosses, labeled as towers | 5 |
| | or forts) in relation to small economic sites (red circles) and activity- | |
| | facility sites (black triangles) | 222 |

| 77. | The map of the EB I-III military sites (blue crosses, labeled as towers | |
|-----|--|-----|
| | or forts) in relation to small economic sites (red circles), activity-facility | |
| | sites (black triangles) and large economic sites (yellow octagons) | 224 |
| 78. | The map of the only EB IV-LB military site (blue cross, labeled as | |
| | tower) in relation to small economic sites (red circles) and activity- | |
| | facility sites (black triangles) | 226 |
| 79. | The map of the IA military sites (blue crosses, labeled as towers or forts) | |
| | in relation to small economic sites (red circles), activity-facility sites | |
| | (black triangles) and large economic sites (yellow octagons) | 228 |
| 80. | The distribution charts for temporal (a), site type (b), elevation (c), | |
| | calculated number of features (d) and landform (e) details of sites that are | |
| | left outside the walking zones from Figures 76-78 | 231 |
| 81. | The EB I-III villages (black outlined yellow boxes), military (blue stars), | |
| | activity-facility (black triangles) and small economic (black outlined red | |
| | circles) sites | 233 |
| 82. | The IA villages (black outlined yellow boxes), military (blue stars), | |
| | activity-facility (black triangles) and small economic (black outlined red | |
| | circles) sites | 234 |
| 83. | The ANOVA chart for villages showing the temporal change in site size | |
| | (p=0.9088). The line connects mean size value of sites in each period | 237 |

| 84. | The ANOVA chart for villages showing the temporal change in site | |
|-----|---|-----|
| | complexity | 238 |
| 85. | The landform distribution of EB I-III (a) and IA (b) villages | 239 |
| 86. | The elevation distribution of EB I-III (a) and IA (b) villages | 238 |
| 87. | The comparison of average precipitation values at EB I-III (a) and IA (b) | |
| | villages | 240 |
| 88. | The map of IA villages (black outlined yellow boxes), in relation with | |
| | military (black stars), and the villages on the Karak Plateau (black filled | |
| | circles) | 242 |
| 89. | The duplicate of the map in Figure 88 with small economic (black | |
| | outlined red circles) and activity-facility (black filled triangles) sites | |
| | shown | 245 |
| 90. | The map showing villages (black outlined yellow boxes), military sites | |
| | (black stars), small economic (black outlined red circles) and activity- | |
| | facility (black filled triangles) sites | 246 |
| 91. | The general distribution of sites according to calculated size | 247 |
| 92. | The calculated site size distribution in the Chalcolithic (a) and EB IV-LB | |
| | (b) | 248 |
| 93. | The calculated site size distribution in the EB I-III (a) and IA (b) | 249 |
| 94. | The log-log bivariate plotting of the IA number of sites (y-axis) and the | |
| | site size (x-axis) | 250 |

| 95. | The log-log bivariate plotting of the IA number of sites (y-axis) and the | |
|------|---|-----|
| | site size (x-axis) | 251 |
| 96. | The cumulative elevation change map. This map is the result of operation | n |
| | (the modern DEM - the elevation map of the last IA iteration) | 254 |
| 97. | The Hasa sites used for extensive agropastoral land use modeling shown | |
| | on the shaded relief map of the drainage | 258 |
| 98. | The map showing the principal land cover classes at WHS-23, which is | |
| | located on the southern plateau of the Hasa, after 50 years of extensive | |
| | agricultural land use | 260 |
| 99. | The map showing the primary land cover classes at WHS-23 after 50 year | rs |
| | of extensive pastoral land use | 261 |
| 100. | The map showing land cover classes at WHS-165, which is located in th | e |
| | main Hasa channel after 50 years of extensive agricultural land use | 262 |
| 101. | The map showing land cover classes after 50 years of extensive pastoral | |
| | land use | 263 |
| 102. | The map showing land cover classes at WHS-615, which is located in th | e |
| | east Hasa, in the valley of el Ali | 264 |
| 103. | The map showing land cover classes at the site after 50 years of extensiv | e |
| | pastoral land use | 265 |
| 104. | The map showing land cover classes at WHNBS-216 after 50 years of | |
| | extensive agricultural land use | 266 |

| 105. | The map showing land cover classes at the site after 200 years of | |
|------|--|-----|
| | extensive agricultural land use | 267 |
| 106. | The map showing land cover classes at WHNBS-216, after 50 years of | |
| | extensive pastoral land use | 268 |
| 107. | The map showing land cover classes at the site after 200 years of pastoral | |
| | land use | 269 |
| 108. | The bar chart comparing the percentages of principal land cover classes | |
| | after extensive agricultural land use in the Hasa | 269 |
| 109. | The bar chart comparing the percentages of principal land cover classes | |
| | after extensive pastoral land use in the Hasa | 271 |
| 110. | The line chart representation of data presented in Figure 109 | 273 |
| 111. | The bar chart comparison of c-factor values at sites based on the results of | 2 |
| | extensive agricultural land use modeling | 273 |
| 112. | The bar chart comparison of c-factor values at sites based on the results of | 2 |
| | extensive pastoral land use modeling | 276 |

Chapter 1

INTRODUCTION

Research Goals

This doctoral research focuses on the settlement systems in the Wadi el-Hasa (Hasa hereafter), in west central Jordan from the Chalcolithic through the Iron ages (Figure 1). I aim to examine the land use practices in tribal societies during the early metal ages and evaluate alternative hypotheses about the anthropogenic and natural changes that occurred in the drainage through time, and the cultural adaptations of the societies in the face of cultural and natural stress factors (e.g., degradation, periodic aridity) using multi-disciplinary research methods. The goals of my research are to illustrate how these adaptations are reflected by long-term changes in the settlement systems and to infer the causes of social changes within the general context of why and how human-environment interactions evolved through time in an environmentally vulnerable region. I use data from two prior survey projects in the Hasa drainage, in addition to the data from a site-specific survey I conducted. Geographical information systems (GIS hereafter) are used to reveal patterns in the settlement data and interactions between environmental and cultural variables in the drainage during periods of interest, which are then analyzed statistically. I interpret the results in the light of recent approaches to abandonment and heterarchic social organization.



Figure 1. The Wadi el-Hasa as seen in ASTER imagery. The NW terminus is the Dead Sea, the drainage is between the Karak (due north) and the Edom (due south) plateaus.

Intellectual Context

The intellectual context of this study is founded in landscape archaeology and ecological anthropology. Landscape archaeology offers a diachronic analysis of changing cultural landscapes within a dynamic environmental context in order to understand cyclical patterns of environmental change, and their impacts on past socio-economic systems (Wilkinson 2003: 3, 214-215).

The natural and anthropogenic evolution of a landscape, the perceptions of social and natural environments, and the reflections of changing socio-economic systems in that particular landscape are the major foci of this approach. Additionally it seeks to correlate changes in the social landscape with alterations in human-environment interactions and the socio-economic systems in which it is embedded.

Ecological anthropology, on the other hand, examines behavior in cultural and natural contexts with a "systems orientation" perspective. Of relevance to my doctoral research, this includes models past responses to environmental perturbations, especially those affect survival, reproduction, spatial positions and social constraints (Jochim 1990, Winterhalder 1993, Moran 2000). Decisions related to settlement and land use are viewed as responses to systemic landscape changes, which are evaluated in the natural setting of the past environmental and climatic conditions in a landscape.

Research Questions

My research on the long-term changes in settlement systems of the Hasa focuses on several critical questions. The first group of questions is on the settlement locations in general and whether site locations vary significantly by time period. The answer to this question helps in identifying the possible locations that the occupants of the Hasa drainage most commonly preferred. Additionally, addressing this question helps reveal how settlement systems evolved over time. Of particular interest is how groups selectively occupied certain landforms or avoided certain areas of the drainage, and associations between these patterns of settlements and environmental conditions or socioeconomic organization in a given period. The second question is whether security periodically became a significant factor in choosing site locations. The answer helps to demonstrate possible fluctuations in social tensions among groups in the Hasa due to competition for resources. Additionally, the density and location of military sites helps point out the external relations of the Hasa population including the role of trade routes. The last, and related question of this group is whether the site locations and major trade routes are additionally correlated. The answer contributes to a better understanding of the role and significance of long-distance trade relations for the Hasa population from one period to another. The role of long-distance trade in a period, in turn, reflects the level of integration of the Hasa with the neighboring regions. Such external interactions are especially important for the direction and scale of social change.

The second group of questions focuses on the site sizes and settlement types. The changing site size from one period serves to indicate fluctuations in settlement patterns (i.e., aggregation and dispersal of sites), type and intensity of subsistence in the Hasa and ultimately signal changes in demography of the wadi when all these factors are combined. Such periodic oscillations can be indicators of natural and/or anthropogenic stress factors such as degradation, erosion or drought. Additionally, the temporal changes in settlement types as well as the diversity of site types at a given time period provide clues about changes in the intensity of land use. Such shifts are compared with socioeconomic, political and environmental variables for a more complete reconstruction of changing anthropogenic strategies on the landscape through time.

Theoretical Approaches

My research uses two groups of theoretical approaches. The first group of theory centers on abandonment and views such events as parts of social, economic and political reorganization processes. Nelson's *Mimbres Model* (2000) is based on the earlier works in the U.S. Southwest of Cordell and Gumerman (1989), and emphasizes that

abandonment is a deliberately planned, strategic decision of a society, which turns unsustainably large settlements in environmentally vulnerable regions (i.e., arid climate, widely dispersed resources) into smaller, economically self-sufficient settlements.

Focusing on much larger, state-level societies, Tainter explains the economic aspect for social reorganization using the concept of energy in his *Economic Model* (1990). In this framework, as social organizations become more complex the system becomes hypercoherent. This reduces the flexibility of the system as well as creating a deficit in the energy production (i.e., the energy created in the system remains lower than the energy spent) (1990: 92). In time, societies either decide or are forced to change the scale of organization, from more complex to less complex, in order to revive the economic system and reverse the deficit in energy production (1990: 93).

A second group of models focuses on the social structure of tribal societies: what the internal components are, how social change emerges, and how social complexity may arise in these seemingly egalitarian agropastoralist societies. Marfoe's *Dimorphic Society* concept discusses pastoralists and agriculturalists as economically symbiotic but politically polarized tribal groups in environmentally marginal regions like southern Syria and southern Levant, where topography is highly dissected, the climate is arid and the resource availability is low (1979). In this framework, the demographic structure of a society is highly fluid. The *Heterarchic Society Model*, developed by LaBianca (1990), Chesson (2003) and Greenberg (2003a; 2003b) explains this fluidity as tribal groups developing strategies of cooperation and competition for limited resources using lineage and kinship ties. By heterarchic, they mean that lineages determine cooperation (i.e., group aggregation, fusion) or competition (i.e., group dispersal, fission), largely in response to environmental variables. The cycles of fusion and fission, diverse subsistence systems and the autonomy of lineages in decision-making process make the flexible social organization highly resilient while creating a heterarchic pattern.

Unlike Mesopotamia or the coastal plains of the Levant, the archaeological record in the southern Levant does not provide material evidence for social complexity during the early metal ages. On the other hand, Johnson proposes that social complexity is not always restricted to state-level societies with hierarchic social organization. The Scalar Stress Model (Johnson 1982) suggests that as group grows, the inherent limitations of human brain to exchange and process information affect the decision-making abilities of the group. In response, the group size and decision-making bodies adjust to information processing needs through cycles of fusion and fission. As the basal unit shifts from nuclear to extended families to deal with the communication stress, the need for consensus among the group members at different levels of social organization creates a temporary, situation-dependant hierarchy of decision-making. The hierarchy may become more institutionalized in these groups when the leaders use their executive powers to widen their economic networks within and outside the society (i.e., wider networks, better connected people), which gradually create an economic imbalance favoring the few people in charge. Bentley's approach to emerging social inequalities in non-hierarchic groups fits well with Johnson's perspective. Bentley discusses how the scale of an agent's social network is directly proportional to the agent's popularity in a society (i.e., Scalefree Networks) (2003a). In small-scale societies, leaders tend to use their influence in

setting up new ties, which usually brings more economic gains; this creates "rich gets richer" scheme (Bentley 2003b: 27). Bentley's method shows how material culture can serve as proxy for social complexity and will be used for testing the signatures of social organization at temporal scale (i.e., comparing the EB and IA).

Research Area

The Hasa offers a unique case study for understanding the dynamics of settlement abandonment and changes in social complexity because of the region's transitional climate, distinct topography, and marginal geopolitical location. The Hasa is located at the southwestern edge of the Irano-Turanian steppe vegetation, bounded on the east by the Arabian Desert (Figure 1, Harlan 1988; Hill 2002). The annual variance in rainfall is between 300 and 600 mm/year (Hill 2006: 8). Long and dry summers; short and rainy winters favor shrubs like artemisia, but numerous springs support mesic Mediterranean flora in patches along the wadi bed (Schuldenrein and Clark 2003: 1-3). Grasslands diminish to the southeast and deflated land surfaces are observed (Schuldenrein and Clark 1994; Schuldenrein and Clark 2003).

The Hasa has widely varied and highly dissected topography. Lacustrine marls and limestone dominate the east (the Upper Hasa), whereas on the west (the Lower Hasa), extensive alluvial terraces and talus deposits are observed due to long-term erosion and deep incision are observed (Schuldenrein and Clark 2001; Schuldenrein and Clark 2003).¹ Today, the Upper Hasa is more suitable for low-intensity seasonal

¹ See Hill (2006: 81) for the impacts of the Holocene climatic and anthropogenic factors on the wadi morphology of the Hasa, especially during the EB.

pastoralism while the Lower Hasa has been the locus of agricultural activity (Hill 2006: 73-89). To the north and south of the drainage are the Moab (Karak) and Edom plateaus. The Karak Plateau receives more rainfall, is much less dissected, and is geologically more stable than Edom Plateau with thicker and richer soil for agriculture (Hill 2006: 40-43, 68-69).

The marginal climatic, environmental, and topographic characteristics of the Hasa made the area a periphery in terms of geopolitics and socially complex political entities (i.e., the territorial states of Moab and Edom), which first emerged in southern Jordan during the Iron-II phase (ca.900-539 BC). Although site numbers increase exponentially and site type diversity peaks during this phase in the Hasa, there are no cities. Rather, numerous large villages and many military sites exist –possibly- to protect and take advantage of trade routes. The settlement systems and other archaeological data indicate that social organisation remained predominantly tribal throughout the prehistoric and historic periods (Hill 2006: 29-30).

These environmental, topographic, and socio-political aspects bring into focus land use and resource procurement patterns at the Hasa. Resident social groups continuously oscillated between short-term cooperation and long-term competition, paralleling the tribal groups' fluid demographic patterns of aggregation and dispersal for survival, and creating cycles of expansion and contraction in settlement systems.

Overview of Research Methods and Data

This research uses the survey data from Wadi el-Hasa Survey (MacDonald 1988) and Wadi el-Hasa North Bank Survey (Coinman 1998 and 2000) projects in 1980s and 1990s, which provide a wide range of information for every site discovered from the Palaeolithic to the Ottoman period. Additionally, I conducted a site survey in the fall of 2007 in which I mapped the features and landforms at selected sites dating between Chalcolithic and Iron ages.

I use GIS-based analysis to identify past land use patterns, modes of production and to assess their probable impacts on the environment by using spatial (i.e., site type, size, density, preferred locations) and environmental (e.g., erosion modeling) data. Through the assessment of possible relationships among terrains, landforms and the spatial distribution of sites, valuable insights can be gained about the past land use and perceptions of the environment on the bases of soil types, geology, land cover and watersheds (Hill 2002 and 2006). Detailed maps of select sites from my 2007 survey and from satellite imagery help reconstruct the function and size of the sites (Figure 2). Moreover, optically stimulated luminescence (OSL) dating samples were taken from three sites in 2007 in order to establish more secure chronological benchmarks in the Hasa.



Figure 2. The site of WHS-23 El-Mashmil in the west Hasa with archaeological and natural features mapped on ASTER imagery and pointed by arrows.

Climatic data (i.e., temperature and rainfall), modeled at 100-year intervals², make it possible to model changes in terrain and land cover for the Hasa at higher resolution than is normally possible from archaeological and paleoenvironmental proxy data. Climatic conditions favorable for dry farming seem associated with the expansion of settlements into sensitive ecotones, while the contraction of occupation into selective areas (see Figure 70 and related discussion) and landforms took place under less favorable climatic conditions. The assessment of settlement systems (i.e., site distribution, characteristic/types) document adaptations under changing climatic and

² This was completed for the Hasa by the Mediterranean Landscape Dynamics (MEDLAND) Project. See the Methodology chapter for the discussion.

environmental conditions, and reveal the impacts of such climatic changes on agropastoralist societies and the sustainability of different economic strategies in the changing environment of the Hasa.

The application of statistical methods, such as One-way analysis of variance (ANOVA hereafter), help to document patterns of settlement and land use in specific zones of the Hasa during certain periods in addition to illustrating changes in site distribution through time with respect to landscape characteristics. Temporal changes in occupation densities (i.e., population aggregation/settlement contraction and population dispersal/settlement expansion) in different areas of the Hasa may indicate adaptation to changing environmental conditions of the wadi and the relationships between population aggregation/dispersal and settlement contraction/expansion are clearly defined in the following chapter under the Hasa Synthesis. The clustering of sites and other patterning discussed above can provide further support for the fluidity of the tribal social organization (i.e., aggregation/dispersal) in the Hasa in relation to resources used and ecotones inhabited.

Organization of the Dissertation

My dissertation has seven chapters. The second chapter provides a contextualized overview of relevant theoretical frameworks about abandonment, social structure and change in tribal societies. I also discuss Hill's model for the long-term land use patterns in the Hasa (i.e., from the Palaeolithic to the Ottoman periods) before providing my synthesis for the Chalcolithic through Iron ages. The differences in both theoretical approach to answering questions and the time scale make the two researches distinct but complementary.

The third chapter focuses on the history of archaeological and palaeoenvironmental research in the southern Levant, in which I discuss the development of relevant archaeological research as well as how the proxy data (e.g., climate, palynology and geology) on the ancient environment of the region have been compiled.

The fourth chapter deals with the methodology of my research. I briefly present the history of my data; how I compiled and managed the data set. After laying out the research questions and discussing the associated hypotheses, I explain how I tested these using GIS and statistical tools.

The fifth chapter presents the results of statistical and GIS analysis, which focus on the temporal patterns of change in the settlement systems and in the environment of the Hasa. I discuss the temporal distribution patterns of settlement locations with respect to critical environmental variables such as slope and landform types. I also scale the settlement data according to these factors and explore temporal changes in settlement density in order to make more accurate comparisons and clarify land use intensity and patterns among the different categories of data. The watershed maps are important for understanding the spatial distribution of sites in relation with reliable water sources as well as revealing significant data about rates of water accumulation. Based on these, I evaluate the changes in the type and intensity of subsistence in the Hasa through time from the perspective of land use. The environmental (i.e., temperature, precipitation, and elevation) variables are also analyzed in this chapter. The results of the Macrophysical Climate Modeling –MCM hereafter and see the Methodology chapter for the discussion– of Bryson and DeWall (2007) for the Hasa are presented as precipitation and temperature maps at 100-year intervals, provide crucial information to contextualize the spatiotemporal changes in the settlement systems of the Hasa. Elevation data from the early metal ages are used in order to reveal the general patterns and in order to test the significance of this variable in other aspects of settlement systems such as internal complexity of sites.

The sixth chapter focuses on presenting the results of GIS and statistical analyses from the perspective of social factors of change and human responses. The analysis of military sites data aim to reveal how the functions of military sites (i.e., protecting sites vs. protecting economic infrastructure such as trade routes) changed through time in the Hasa and how the military site organization evolved towards the establishment of a "network". Both in relation to the military sites and as an evaluation of the IA peripheralization theory, I also analyze the settlement patterns from the EB I-III and IA with a specific focus on the large economic sites. The relationship among the large economic sites and others (i.e., military, small economic, activity-facility sites) reveal interesting patterns of change through time, especially in the IA. These IA changes are, then assessed from the perspective of social organization strategies (i.e., scale-free networks) to explain how social complexity in the marginal landscapes of the southern Jordan may emerge. The landscape evolution maps show how climatic and other environmental variables such as land cover, soil erodibility affect the long-term changes of the Hasa landscape. Combined with the maps of extensive agropastoralist model, these
results show the combined effects of natural and anthropogenic factors that shaped the Hasa. Finally, the new settlement concept is discussed and used as a measure of resiliency in the Hasa. Consequently, both chapters five and six aim to illustrate how oscillating productive capacity of the Hasa sites relates to changes in tribal social complexity and risk management (i.e., to avoid land degradation due to over-exploitation) tactics.

The final chapter provides the concluding thoughts and comments on the land use, tribal social organization and social change through time as results of socio-economic adaptations to changing environmental conditions in the Hasa due to natural and anthropogenic factors. The Hasa Synthesis is assessed in the regional context before the broader research impacts are argued.

Broader Impacts

The major contributions of this research can be summarized as follows: (1) the wide topographic and climatic changes within the Hasa have the potential of documenting different settlement systems and land-use patterns in prehistory; (2) the Hasa has the potential of illustrating how different adaptations were used at different periods as risk-minimizing behaviors (e.g., changing emphasis from agriculture to specialized pastoralism and vice versa) in an ecologically vulnerable area; (3) this research has the goal of identifying "anthropogenic landscapes" through settlement and land-use patterns, which may reveal various dimensions of the human-environment relationship (including human agency) and observing unintended consequences of land-management strategies in fragile ecotones in the long term; (4) it may be possible to

interpret abandonment/re-settlement from a wider perspective of human-environment interaction with emphasis on long-term social and natural co-evolution in the Southern Levant; (5) this research combines geo-archaeology, palaeoenvironmental reconstruction, archaeology, and spatial data processing; the explanatory power offered by this interdisciplinary research design exceeds that of a research design that relies upon a traditional, culture-historical approach; and (6) the research design, the questions, and the methods complement the MEDLAND Project (supported by NSF's Biocomplexity in the Environment Program, under the direction of C. Michael Barton), which is the interdisciplinary study of long-term human adaptation during the Holocene in the Mediterranean Basin. The results of the Wadi el-Hasa research should provide important insights to MEDLAND about the complex, time-transgressive relationships between people and the social and natural environment.

Chapter 2

THE THEORY OF ABANDONMENT AND RESETTLEMENT

Introduction

This research focuses on the two aspects of past human socio-ecosystems in dry lands: the cycles of abandonment of settlements and the changes in tribal social organization as group sizes shift between aggregation and dispersal. I studied both processes in the mutual and dynamic context of human-environment interactions, where the changes in one have direct and indirect consequences on the other. These relationships characterize the social organization, the settlement systems and the patterns of land use of a society. Therefore, theoretical approaches to abandonment and changes in social organization are important frameworks for interpreting data presented in this dissertation. However, before discussing the pertinent approaches in detail, it will be helpful to provide an overview of how social change and abandonment have been perceived by earlier approaches in history and archaeology.

Overview

The concepts of collapse and change in societies have long been the foci of scholarly debates. The earliest evidence comes from the Greco-Roman periods with the writings of the first philosophers such as Plato and Polybius, who propose that civilizations are similar to organisms with a naturally limited life expectancy. By the beginning of the 20th century the *Social Cycle Theory* of Oswald A. Spengler places emphasis on the repetitive and cyclical nature of events and stages in history, which is evident in his categorization of the past as the Golden and Dark ages, especially in his

most influential publication, the *Decline of the West* (1961). During the first half of the last century *Environmental Determinism*, championed by Ellsworth Huntington, employed the concept of a non-human prime mover in seeking explanations to social differences and change in his books such as *Civilization and Climate* (1924) and *Mainsprings of Civilization* (1945). Although Huntington is the first historian who uses various sources of information such as geology, climate and topography to construct his theory, it places major emphasis on the role of the environment in society and social change.

In archaeology, collapse, abandonment and social change in my study region was commonly attributed to exogenous factors such as the Amorite invasions (Kenyon 1966), which brought destruction and social unrest to the northern Mesopotamia around the end of the Early Bronze Age (ca. 2,300 BC). Typically, the focus of these earlier explanations for change was on single variables rather than more complex and multifactored explanations for events or processes leading to these events. Moreover, there is no differentiation between collapse and abandonment.

Following a major paradigm shift in archaeology to a more scientific, hypothetico-deductive research design, with the rise of the "New Archaeology" in the second half of the 20th century, scholars like Binford (1968) and Flannery (1968) introduced *General Systems Theory* (GST) as a basis for understanding socio-ecological change. GST views culture as a system of interacting institutions such as social organization, economy, technology and ideology (Binford 1968, Trigger 2006). As such social change is studied with respect to the rate and direction of change in the sub-

systems and their overall impacts on a culture in general (Binford 1968: 5-32). Notions such as resistance, resilience and coherence along with feedback mechanisms are used to explain the social change (Trigger 2006: 418-422). The notion of change in the New Archaeology relies heavily on the idea of adaptation to ecological change (Trigger 2006: 410) and the perception of collapse, within this framework, is viewed as a failure to adapt to changes in the conditions that are surrounding the cultural system mainly because of hypercoherence among the institutions that reduces the adaptive flexibility of the system. However, this approach generalizes rather unrealistic idea that catastrophes almost always cause collapse (i.e., demographic, ecological and economic) (Trigger 2006: 412). Along with an increased emphasis on culture as societies or social systems was the recognition of the importance of a multidisciplinary approach for understanding longterm transformations in nature-culture interaction, and the way in which behavioral change emerges in the natural context. Starting with Robert Braidwood's research in the Iraqi Kurdistan (Braidwood and Howe 1960), the combination of wider sources of data and stronger analytical frameworks afforded by multidisciplinary research allowed more detailed reconstructions of past life ways, and offered fresh insights into how these systems may emerge and come to an end. In that sense, the multidisciplinary approaches represent the most inquisitive phase of archaeological research -not only for understanding the social change, abandonment and collapse as individual events, but more importantly as the objects of scientific research to reveal processes associated with them.

In summary, the evolution of perspectives on the social change, abandonment and collapse shows a trend from the use of prime movers and ignoring the processes behind these events to multidisciplinary research strategies which pay attention to how different processes lead to different events in terms of change in a society, abandonment or collapse. Having provided an overview of how abandonment and social change concepts are perceived by the earlier approaches, it is necessary to discuss the relevant theories to my research.

Abandonment

Until the last decades of the previous century, the concept of abandonment has been perceived as a complete end of a settlement's life due to military conflicts or catastrophic events. Commonly, the reasons of abandonment have been superficially explained and, the process of abandonment or the fate of societies in the aftermath has rarely been discussed.

<u>Abandonment as a Social Strategy:</u> Recently however, new methods and theories have been proposed and initially tested in the field. The U.S. Southwest is one of these places where archaeologists have applied these new field methods and interpretive frameworks for the evaluation of evidence for abandonment in wide ranging data. Cordell and Gumerman (1989) identified the climatic and economic context of settlement in this region, which had diverse topography with semi-arid to arid climate. Rather than focusing only on abandonment, Cordell and Gumerman correlated climatic and economic variability over time and space with shifts in settlement systems and, with the help of the well-defined chronology of the region, to identify five different periods of settlement activity in the region between AD 200 and 1540. These settlement periods showed different levels of land use intensity, group mobility (i.e., settlement expansion and contraction), social dynamics (e.g., group fusion or fission) and stylistic homogeneity. The variations in settlement patterns clearly showed resilient aspects of societies and how they survive through adjusting the settlement and subsistence intensity continuously in the region.

The *Mimbres Model* of Nelson (2000) extended Cordell's work, focusing on the Classic Mimbres settlements (i.e., villages from the twelfth century AD). This model also viewed abandonment not as an end to a cultural entity but as a necessary reorganization in social and settlement systems; a perspective, which was also shared by Cordell and Gumerman. Nelson emphasized that societies occupying arid lands are frequently faced with natural and economic challenges, including periodic aridity, lack of vital resources, and risks associated with subsistence practices. In order to survive under these conditions, large settlements sometimes had to be reorganized (Nelson 2000: 58). This reorganization could involve the dispersal of population from large, unsustainable settlements (i.e., villages and other locales of population aggregation) to smaller, sustainable ones (e.g., hamlets). Abandonment, then, was viewed as a strategy to adjust long-term land use in relation with demographic shifts, and as a socio-political transformation that requires negotiation and microdecisions, usually based on gender and social class (Nelson 2000: 55). These qualities of abandonment, and the attempt to account for behavioral and social change at varied scales, required less normative approach than the preceding approaches to this concept (Nelson 2000: 55). In these approaches, the abandonment behavior then is studied in terms of *processes* (changes in settlement systems), *scale* (regional vs. local abandonment), *temporal extent* (permanent vs. temporary), and *use of places* (complete abandonment vs. continuing use of ritual places) (Cameron 1993, Tomka and Stevenson 1993, Schlanger and Wilshusen 1993, Nelson 2000).

This approach to abandonment also attempted to correlate cumulative effects of various events leading to such behavior with the reasons why and how societies made this kind of decisions at different spatio-temporal scales. This contributed to our understanding of how critical survival decisions were made in the face of environmental and cultural stress factors. Although it addressed the social aspects of such decisions (i.e., the social organization and group mobility), the economic reasons are not explicitly discussed even thought they represent an important factor in all decisions related to socio-political life. Therefore, it is useful to extend this perspective by combining it with the *Economic Model* of Joseph Tainter.

The Economic Perspective: Tainter views social change towards complexity as a mechanism of problem solving, which usually emerges as results of conflicts (i.e., internal or external -environmental circumscription as Carneiro (1970) used-) the need for managerial institutions due to the growing size of population and diversity of decisions to be made, or a combination of these factors (Tainter 1990: 32-33, 93, 118). The members of the complex society (i.e., a political entity with economic and cultural heterogeneity) initially enjoy the benefits of growing economy. However, the economic costs associated with social complexity increase through time, posing a risk for the survival of the social complexity.

Tainter emphasizes a relationship among the changing scale of economic growth, abandonment and collapse. He focuses on the multi-faceted processes of collapse in complex societies by examining the amount of energy created and used by the system (i.e., social, political and economic organization in a culture) as well as the feasibility and sustainability of the methods to harness this energy (Tainter 1990: 91). His argument of collapse is based on relies on the Law of Diminishing Returns in the field of economics (Hadar 1966; Hailstones 1976; Tainter 1990). It is proposed that once the economic growth in society reaches to a level where it cannot be sustained (due to population increase, environmental and/or socio-political reasons), the existing socio-political system may collapse and it can be replaced by a different economic system that generates more wealth (Tainter 1990: 126).

This path to economic deficiency and political collapse is tied to some important concepts. The "Average Product" is the *per capita* production (i.e., output) in relation to input. The "Average Cost" is the cost per unit of input. The most important concept in Tainter's perspective is the "Marginal Productivity", which refers to the total *increase* in output per increase in input (Tainter 1990: 91-93 and Figure 1). In this framework, a society needs to maintain a certain rate of increase in productivity (i.e., marginal productivity), in relation to the amount of labor and return (i.e., input and output) so that the economic growth takes place (Tainter 1990: 91-93). The use of machinery, instead of manual labor, can be an example of how the rate of productivity is exponentially increased in agricultural societies while keeping costs lower by using the same labor force and spending energy efficiently. The society, at this point, has a growing economic

system; using the resources that are easily accessible provides maximum economic return at low cost (Tainter 1990: 94, 120). Although it is sufficient to maintain the same rate of marginal productivity for the society to retain the status quo complexity level, this is not a realistic expectation. In time, the economic system may grow inefficient due to population increase, decline in yields due to environmental degradation, and other reasons (Tainter 1990: 110-111). This becomes evident in the declining rate of increase in productivity (i.e., the drop in the marginal productivity). The society that had a growing economy (i.e., increasing rate of marginal productivity) in the past is now barely able to produce the same amount of goods (or, produce) using much higher number of people and spending much more energy (Tainter 1990: 94-95, 116).

This new economic situation can be summarized as making inefficient use of less accessible resources, at much higher costs to produce the same amount as the previous phase (Tainter 1990: 95, 116). The society at this stage realizes the decline in economic growth, due to drop in the marginal productivity and assesses the benefits of the existing socio-political system (Tainter 1990: 93). The increased costs of the socio-political complexity may be reduced through technological innovations. However, such advances require major economic investments and are not guaranteed of success (Tainter 1990: 108-110). Under these conditions, generally, the economic system cannot continue to grow (i.e., output) relative to its costs (i.e., input); the decline in marginal productivity is coupled with diminishing average product (i.e., the average return is less than average input); both *per capita* and *total* productivity of the society decline. This in turn, may affect the survival of the social system; the financial stress and political perturbations

may lead to social disintegration and re-organization at a less complex level (Tainter 1990: 121-123). The rise of autonomy, shift to ruralism and emergence of self-sufficiency along with the reappearance of long suppressed regional traditions are trademarks of this reorganizational phase (Tainter 1990: 20).

Tainter's model was originally developed for societies at the state level, and such systems have more complex levels of creating and maintaining high energy levels to keep up the system. The assumptions of the model about societies without environmental circumscription in the post-collapse phase are the most relevant to my research on the Hasa. If there is land available to the society, then a feasible way to increase the marginal productivity is to spread out (Tainter 1990: 123). This reduces cost of information processing, increases efficiency and makes smaller social groups more sustainable.

Tainter's Economic Model offers a useful framework for research on the evolving fluidity of human socio-economic dynamics within the tribal societies in an environmentally marginal landscape of the southern Levant (i.e. the Hasa). It especially helps to explain how the social and political mechanisms for rectifying declines in economic productivity are reflected in settlement patterns and contracting and expanding settlement systems from the Chalcolithic to the Iron ages.

Abandonment and social reorganization are both major types of social change. They both have been used as strategies of survival and risk minimization in the historic as well as prehistoric periods. As communities negotiate and make relative decisions about these among themselves, they go through changes in terms of social organization. Additional theoretical approaches about how and why change happens in tribal societies are discussed in detail in the following section.

Social Change

The "abandonment as social reorganization" concepts discussed above focus to only a limited extent on socio-economic and political factors that structure the social change. In order to explicitly discuss the changes in social organization as reflected in settlement systems following abandonment, my research focuses on three separate but interrelated concepts on social change regarding the tribal societies: the dimorphic society, heterarchic social organization and the emergence of social complexity.

Dimorphic Society: This concept, introduced by Marfoe (1979), emphasizes that the regions with wide environmental and topographic variations (i.e., southern Levant, southern Syria) create numerous microenvironments. These microenvironments support diverse set of ecological relationships and socio-political behaviors, and which lead to a wide variety of local adaptations and subsistence practices (e.g., terrace agriculture, horticulture, dry farming, steppe pastoralism, vertical nomadism), as well as different settlement systems without apparent signs of hierarchy (Marfoe 1979: 3-7).

The *Dimorphic Society* concept is valuable to my research for two reasons. First, it identifies two distinct groups, nomadic pastoralists and the sedentary agriculturalists, which are in symbiosis economically but polarized politically. In the absence of a hierarchical social framework, the pastoralist component especially brings elasticity to the tribal social organization, making inter-group coalescence less problematic by establishing ethnicity and kinship as the ultimate social bonds (Marfoe 1979: 7, 9, 12).

Second, it emphasizes fluid demography (i.e., group fusion and fission), largely as a factor of environmental conditions (Marfoe 1979: 12). Non-hierarchic small social units in the region are able to create larger political units through fusion. However, resource availability, climatic parameters and other ecological factors may act on the social characteristics (i.e., fluid demographics, diverse subsistence, tribal organization). Fission (e.g., dispersal into small social groups) then becomes a mechanism to reduce the centrifugal tendencies in the nomadic pastoralist social base, which emerges at times of environmental stress (Marfoe 1979: 35).

Heterarchy Model: First articulated by LaBianca (1990) in the context of The Hesban Project in central Jordan, the heterarchy model is complementary to the concepts of Marfoe's *Dimorphic Society*. The model focuses on the complex, patterned and interconnected activities in a society for procurement, processing, distribution and consumption of food (i.e., the "food systems") in order to document and fully understand cycles of intensification and abandonment (LaBianca 1990: 6-10). According to LaBianca, such cycles are results of diverse environmental conditions that encourage various subsistence systems to emerge in symbiosis. Political aggregation (i.e., group fusion) occurs when environmental and climatic conditions are favorable, while dispersal (fission) takes place when these conditions are reversed (LaBianca 1990: 34-40).

Significant aspects of the model for the social organization and settlement systems during the early metal ages in the Hasa are discussed by Chesson (2003: 83), who defines heterarchy as a social, economic, and political system in which the villages (i.e., composed of households from different kins) acted as dynamic and complex units in

a variegated landscape, where the steppe to semi-desert climate did not allow for largescale centralized states or rigid hierarchies. In this framework, each household aims for survival and households are both cooperating and competing for access to resources using social networks (Chesson 2003: 86). The cooperation may bring supra-household social organization with corporate power strategy. Corporate power strategies require collective labor and sharing of power to make decisions –while individual kins reserve their rights to access ancestral lands and resources– which in return provides long-term stability and continuity of the economic system (Chesson 2003, Philip 2003). These aspects of the model constitute a resilient, dynamic and flexible social organization in adaptive responses, decisions, and actions (Greenberg 2003a, Greenberg 2003b).

The heterarchy model also has the capacity to illuminate spatio-temporal changes in multiple strategies of the kin for socio-economic, political and religious practices with respect to the decisions made by the basal social unit (i.e., the house therefore, the kin). It describes how the dynamic relations (e.g., cooperation, competitions and negotiations) within a village reflect the social actors' (i.e., kins or individuals) decisions. (Chesson 2003: 82-84). These aspects of heterarchic social organization affect the development of tribal solidarity, identity, and cultural autonomy through social interactions, cooperation and competition for resources as well as negotiations within the corporate power strategy framework mentioned above (Greenberg 2003a: 26).

In the context of my research, tribal dispersal/aggregation mechanisms of the Heterarchic Model are associated with abandonment and social re-organization. Moreover, they are inherent strategies of autonomous, self-sufficient groups (i.e., tribal societies) with diverse subsistence bases, highly varied settlement patterns, and locally specialized economies for survival in marginal landscapes.

Identifying Prehistoric Social Complexity: Johnson (1982) emphasizes decision-making, information exchange and organizational scale as key parameters for evaluating how complex social organization emerges from small scale, task-oriented societies. The critical factor is the group size, which may foster an exponential increase in set of relationships and potential exchange of information (Johnson 1982: 392). His results suggest that information processing and decision-making degrades as groups exceed an average of 6 individuals, an organizational threshold inherent in capacity of human brain to monitor and process information (Johnson 1982: 394). The solution to the "scalar communication stress" that Johnson proposes is either through putting a smaller proportion of the group in charge of decision-making permanently or creating temporary decision-making hierarchies through cycles of fusion or fission, along with kinship ties, to improve the quality of decision-making and reduce the stress (1982: 396). Group fissioning is common in the face of scalar communication stress, especially in pre-state polities, unless social or environmental circumscription is evident (Johnson 1982: 408). Tension is reduced by the re-adjustment of the type and size of the basal unit; the shift from extended to nuclear family (Johnson 1982: 403). In these cases, the consensus among the group members is actively sought, instead of coercion (Johnson 1982: 413). Johnson's approach to the emergence of transient or permanent social complexity in egalitarian groups clearly illustrates the capacity and alternative paths to complexity on the basis of stress in dealing with information processing in small-scale societies.

Several other studies offer useful conceptual methods for identifying the social patterns of interaction and complexity. Harrison and Savage (2003, Savage, Falconer and Harrison 2007) use K-Means cluster analysis to identify six distinct clusters of the Early Bronze sites displaying low level of settlement integration and lack of centralized settlement networks. Small agricultural villages actively participated in production and consumption through de-centralized crafts, following local demands and intricate regional exchange networks within the heterarchical social organization (Harrison and Savage 2003: 49). Analysis of the Early Bronze regional settlement indicate that the southern Levant is the hinterland for the coastal plains, always remaining flexible and autonomous, and relying on a self-sustaining and diverse economic base that makes the culture resilient and enduring (Harrison and Savage 2003: 51). My research focuses on factors such as group size, information processing capacity, the level of interconnectedness among the individuals in the social group in discussing the emergence of social complexity within the heterarchic social organization concept.

Prehistoric Social Complexity: Bentley illustrates how social network characteristics can help identify hierarchical and heterarchical social organization by building on the concepts of "Small World" and "Scale Free Network" (Bentley and Maschner 2003; Barabasi 2009). Both concepts are used in the complexity theory to explain how interacting agents establish relationships, make decisions and consequently contribute to social change, via the growth of social networks, through time (Bentley 2003a: 18-21). The basic tenet of subscribers to these concepts and theory is that the change in a system (i.e., society) occurs at all scales and usually at a gradual pace (Bentley 2003a: 14). The

driving factor behind this pattern is the fact that in small world (i.e., highly connected, random) networks, initially most agents establish direct contacts with a neighbor and only a few agents have high numbers of contacts (Bentley 2003b; 28-29), which reduces the probability of cascading (i.e., sudden and large-scale) changes (Bentley 2003a: 20) due to the randomness of connections in the network. As the network grows, each agent's number of contacts shows proportionate increase to its initial stage. The few agents with higher number of relationships can establish new relationships more easily than the remainder of the group and they tend to become more desirable in the social network, which is called "Preferential Attachment" (Bentley 2003b: 30) and gives them the role of 'hubs' in the network (Bentley 2003b: 30). The mathematical expression of these changes in the topology of the network (i.e., the number and distribution of nodes established by each agent) can be illustrated with the help of power-law distribution, which plots the number of interactions and the agents interacting at log-log scale (Figure 3, Barabasi 2009: 412).



Figure 3. An example of the power law distribution where nodes are ranked according to the number relationships they have. Only few nodes maintain high number of relationships and they become 'hubs' (adapted from www.macs.hw.ac.uk/).

The typical result for scale free networks is a negative linear relationship when nodes vs. attachments (or other relevant social phenomena) are plotted on log-log scales (Bentley 2003a: Figure 1.5), which reinforces the preferential attachment phenomena; few agents have the highest number of interactions and the majority has far fewer. The scale free network concept is not only significant for explaining how a complex system evolves in time on the basis of relationships established, but also it can clarify the emerging social differences (Bentley 2003b: 35-41). As few agents, whose extensive relationships across the network begin to expand and allow them to establish newer contacts, this minority gains economic advantages over the rest of the network on the basis that their contacts allow them to engage in new activities and seek economic opportunities (Bentley 2003b: 35). The 'rich gets richer' analogy refers to this process (Bentley 2003a; Bentley 2003b). This is especially true in societies where competition is more emphasized due to resource shortages and subsistence patterns, such as pastoralists in the arid regions (Bentley 2003b: 37). As a result, scale free network concept addresses how the exploitation of economic ties by the few influential people in a small society (e.g., tribal leaders) may increase their political power.

Bentley's *Scale-free Networks* model has the potential to test the types and levels of social complexity in small-scale societies (e.g., the agropastoralists). The identification of social complexity is challenging in archaeological research –especially in the context of task oriented, small-scale societies- and Bentley's model shows how material culture can serve as proxy for social complexity and its application to Hasa is discussed in the Methodology chapter. My research on the Hasa uses Johnson's and Bentley's approaches to test and evaluate how strategies of cooperation and competition in small-scale societies, living in an environmentally vulnerable area with limited and dispersed resources, shape the decisions of people and what their implications may be for types and levels of social complexity (i.e., group size and the measure of connectivity of agents).

Remote and Local Decision Making

Hill's research on the long-term (i.e., from the Neolithic through the Islamic periods) abandonment and resettlement patterns of the Hasa assigned a peripheral role to the area within the context of periodically emerging regional social complexity (e.g., state-level formations around the Hasa). Hill also emphasized a tribal social organization

and proposed that tribes were forced to exploit resources intensively when under foreign political dominance due to decisions made by central administrations that were socially and spatially distant to the Hasa. But when social complexity faded in the region, the Hasa tribes were able to make their own decisions about land use. These cycles of shortterm maximization and long-term self-sufficiency were associated with temporally changing settlement patterns (i.e., from villages to farmsteads) in the area (Hill 2006: 29-30).

Hill supported his perspective with oscillating numbers and sizes (hence, types) of settlements throughout the periods, and occupation or abandonment of lands at risk for severe erosion. The threefold increase in settlement numbers and areal expansion of sites in the Early Bronze Age (EB hereafter) were interpreted as a real population 'spike' (MacDonald 1988, Hill 2006). This spike was attributed to the "medium low hierarchical authority" (i.e., oscillations between chiefdom and state-level in social organizations) that made decisions for short-term intensive production during the EB (Hill 2006: 63-64). Hill stated that land degradation (i.e., erosion) during this period was most probably due to decisions made by centers that exploited the Hasa as periphery (Hill 2006: 63).

Hill viewed the Middle and Late Bronze (MB-LB) abandonment in the Hasa as a result of more arid climate patterns in addition to land degradation caused by ill-informed decisions made at distant political centers, which might have brought political instability to the area as well (2006: 40-43, 64). According to Hill, these periods represented depopulation (or dispersal) when the occupants of the Hasa returned to self-sustaining land-use methods. The revival of settlement activity in the Iron-II period was explained

by the rise of the territorial states of Moab (north) and Edom (south). Hill showed that the later socio-political entities (i.e., states) in the region periodically overexploited the Hasa as periphery (i.e., the Iron Age, the Nabatean and the late Islamic periods), which caused severe erosion. These were followed by periods of abandonment (e.g., the Hellenistic, Roman/Byzantine, and early Islamic) (2006: 141, Figure 6.14). In general, Hill's model considered abandonment and resettlement in the Hasa as result of both late Pleistocene–early Holocene changes in the valley morphology, vegetation due to climate change, and anthropogenic (including political decision making) impacts of the mid-Holocene (2006: 154). Hill's research of the Hasa settlement systems has been a significant contribution to the anthropological archaeology of dry lands, showing how the socially complex entities of the Iron Age and later periods took advantage of delicate and vulnerable peripheral ecosystems like the Hasa.

The Hasa Synthesis

Within the unique environmental, topographical, and geopolitical location of the Hasa, this research aims to:

- 1) Create a synthesis of the models of settlement reorganization reviewed here,
- Bring an integrated explanatory framework to cycles of expansion and contraction in the settlement systems of the Hasa during the Bronze and Iron Ages,
- Test the framework archaeologically through statistical and spatial research methods.

Hill's research in the Hasa contributes to the archaeology of arid lands by quantitatively assessing how the production systems changed through the Holocene in relation to the socio-political events in the drainage using the approach he developed (Hill 1998). In his study of the Hasa settlement systems, Hill subscribes to the idea that the tribal organization prevails in the region as late as the Iron Age and the economic system in this rural part of the southern Levant avoids over-exploitation, where tribes have no use for surplus (Hill 2006: 29-30). The tribal social organization, diverse and flexible subsistence, and wide social networks allow them to resist the economic maximization at times of foreign political dominancy (i.e., state formations) (Hill 2006: 30) and abandonment is used as a mechanism of disobedience along with pastoralism. The development and testing of such theoretical approach not only reveal how the tribal societies manage various sources of stress – and, more successfully than the sedentary societies – but also illustrate the dynamic nature of tribal politics, social and economic decisions made at different levels and the diverse factors that weigh in such decisions.

This research will test whether signatures of hierarchic or heterarchic social organization persist in the Hasa while considering the probability of oscillations between the two types. I aim to create a socio-political framework that will contextualize the late Early Bronze climatic changes and earlier Early Bronze anthropogenic degradation in the Hasa.

The Hasa Synthesis begins with Nelson's idea of social re-organization through negotiation and microdecisions. The *Heterarchy Model* provides the baseline for the tribal core of the Hasa society, which remained resilient and highly adaptive to major natural and cultural stress factors by maintaining their diverse economic base and fluid demography (i.e., self-sustaining economy and periodic expansion/contraction of settlements). Additionally, Tainter's model contributes the idea that societies, at any level of complexity, attempt to use social and political mechanisms to offset declines in marginal productivity, which directly affect their subsistence base and therefore their survival on the landscape. Abandonment (i.e., population dispersal, contracted settlement systems) is one of these mechanisms that we observe in the archaeological record. Finally, using Johnson's approach to egalitarian groups, the cycles of fusion-fission will be evaluated from the perspective of emerging social complexity, which not only might have helped reduce the scalar communication stress at certain periods but also could have laid the foundation for institutionalized complexity in later periods (i.e., possibly starting with the Iron Age). Bentley's *Scale-free Networks* method therefore, is valuable since it has the potential to reveal social complexity in non-hierarchic social systems.

<u>Aggregation-Dispersal Mechanism</u>: The continuous demographic oscillations between aggregation and dispersal in tribal groups are seen as risk-reduction measures that directly contribute to the social change as people adjust types and intensity levels of economic activities through variety of political and social measures. I will investigate whether or not "population aggregation" is a result of favorable environmental (i.e., warmer and wetter) conditions, which allow tribes to unite their efforts through political alliances toward increased production of food resources and trading goods via supracommunal agro-pastoralism and the establishment of trade networks. The social interaction and cooperation among the tribes not only can bring higher economic returns but also open the door for exchange of ideas and innovations in other areas of daily life. In terms of settlement systems, I will examine whether there are phases of settlement expansion, which is evident in wider variety of site types (e.g., villages, farmsteads, and hamlets) that occupy more diverse ecotones for different resources and varying types of subsistence at different levels of intensity. I also will look into whether larger "tribal centers" (i.e., villages), as Rowton (1976) suggested, are located at climatically and geographically more stable locations (e.g., northern Jordan Valley, Karak Plateau, Hesban), where they could be sources of political and economic influence (i.e., determining the alliances and intensity level of subsistence patterns) in a large territory, as well as being gateways to neighboring regions in the Southern Levant. Such centers are rare in the region; even during the expansion phases (i.e., the EB II-III, ca. 3,100-2,300BC), the settlement systems do not indicate hierarchic integration (Harrison 1997: 21-22).

I explore the nature of possible settlement expansion phases, which may be reflected by the presence of large hamlets and villages. Although as a marginal zone, the Hasa drainage was never fully settled or exploited for its natural resources, the settlement patterns at the Hasa in Early Bronze may suggest that tribal groups were actively involved in agro-pastoral subsistence activities with some level of intensity. Most of the Early Bronze sites show evidence for co-existing practices of herding and agriculture. Agriculture, even today, may provide higher yields than the needs of several households if practiced on wadi beds. The widespread presence of Early Bronze farmsteads, hamlets (and possibly villages³) at varying elevations and on different terrains (e.g., terraces, spurs, cuesta ridges, floodplains) will be investigated for socio-economic implications. These patterns may suggest that the combined natural and cultural factors were so favorable by the early phase of the EB that even a marginal zone like the Hasa witnessed aggregates of tribal groups with various subsistence strategies. It is also possible that the Hasa population in this phase interacted with settlements in other areas, such as the Karak Plateau and Edom through exchange of produce and raw materials.

The settlement patterns described here have parallels in the US Southwest discussed above, where in both cases exhibit a wide variety of subsistence strategies in diverse ecotones with various settlement types. In the southern Levant, population aggregation emerges during phases of intensive land use, which is observed during climatically favorable phases. I investigate whether such aggregations cause overload in information processing and decision-making may also ultimately overload a fragile and changing resource base, which may take the system to the next level (i.e., beginnings of hierarchy) in terms of social organization.

The Iron Age archaeological record of the region indicates the rise of territorial states bordering the Hasa (see Chapter 3). The development of social complexity on the Transjordanian Plateau may be the result of two separate but concurrent processes; firstly the influence of the Israelite state on the west bank of the Jordan River and secondly the

³ Although there is no evidence of such a settlement in the Hasa today, there is great deal of destruction in the area. These villages, presumably located near strategic resources like perennial water source, trade routes, or on alluvial fans, might have been destroyed or the currently visible sites might have been large enough to be villages in the early part of the EB.

unique path for initially non-hierarchic tribal groups to develop complexity. For the latter, I will use Bentley's work on social networks to help identify type(s) of social organization(s) and how they change through time.

I also look into how lack or diminished levels of natural resources affected the sustainability of aggregated settlements. Even minor changes in the availability of water, surface run-off, erosion patterns, and rates of desertification could have directly –and, negatively- affected the survival of aggregated settlements in the Hasa, which were already putting pressure on and degrading the landscape—especially through goat herding.

Well-documented climatic changes toward aridity, increased erosion, and desertification accompany widespread collapse of settlements observed in the archaeological record for the last phase of Early Bronze (EB-IV, ca. 2,300-2,000BC) (Dalfes, Kukla and Weiss 1997). Many scholars believe that the collapse of the Near Eastern Early Bronze urban system was triggered by natural (i.e., climatic) changes, which brought socio-economic crises and social unrest. In the Southern Levant, the collapse was much more severe, as the region was located in a marginal climatic and ecological zone bordered by deserts. The recovery was quick (on the average 200 years) in many regions of the Southwest Asia, whereas in the Southern Levant it took about 300 years. Only few large urban centers survived on the coastal plains and some large settlements in the Northern Jordan Valley recuperated first or started new (i.e., Khirbet Iskender, Tell abu en Ni'aj, Tell el Hayyat).

I also investigate whether "population dispersal" is an option when favorable environmental conditions are completely or partially reversed (e.g., progressive aridity, increased erosion, reduced fertility of soil). Such dramatic changes directly affect socioeconomic and political cooperation among the tribes and nullify the economic and political benefits of aggregation. Therefore, the same decision-making mechanism that opted for aggregation earlier also drives population dispersal (and settlement contraction) across the landscape toward the preferred locations, where vital resources are still available. Inter-group conflicts also may catalyze the dispersal. Dispersal of the population reduces the group size considerably, and groups increasingly compete for a variety of resources as mobility is increased. It is possible that through this economic and political fissioning, a system that had provided dismal returns –reduced marginal productivity compared to energy input– was replaced by a system that was more efficient and offered higher marginal productivity.

The projected patterns for population dispersal, especially the increase in group mobility are seemingly in contradiction with the residential and subsistence patterns offered for the US Southwest. Although groups readjusted social and economic bases under stress, the adaptation in the southern Levant relied more heavily on shifting to pastoralism proposed in the *Dimorphic Society* model and therefore unlike the US Southwest. Group mobility increased while the significance of agriculture dropped. Consequently, I will explore whether the Hasa population aggregated in certain locations, which had valuable limited natural resources. Using Johnson's model, I study whether changes in social organization type was sufficient to deal with the scalar communication stress and decision-making.

The cases of fluid demographic change between the late Early Bronze and Iron ages in marginal areas have been identified and discussed in Northern Syria, at Tell es Sweyhat, by Wilkinson (2004) and at the Khabur Valley sites (Cooper 2006) and in the Jabbul Plain, at Umm el Mara, (Nichols and Weber 2006). In the Hasa, such dispersals are reflected by a near-total abandonment of the area for approximately 1,100 years, from MB (ca. 2,000BC) to the Iron-II phase (ca. 900BC). With the exception of 18 MB-Late Bronze (LB) sites (small economic sites such as farmsteads, hamlets) out of a total of approximately 2,00 sites identified by surveys of MacDonald (Wadi el-Hasa Survey-WHS) and Clark (the North Bank Survey-WHNBS), the Hasa did not show any major settlement activity. Given this record, it is possible that pastoralist groups occupied the drainage with some frequency.

I examine whether the long-term abandonment of the Hasa may be explained in terms of deliberate avoidance of the drainage by tribal groups; specifically around the As-Safi region in the west Hasa, where environment and geomorphology became more unstable under new climatic conditions (i.e., pronounced aridity and channel down cutting). In comparison, the settlements on the Karak Plateau, a zone of relatively more stable environment and geology, did not suffer from climate changes and political crisis at the same rate as the Hasa. The settlement system on the Karak Plateau actually indicates survival of earlier Early Bronze settlement hierarchy at some level (Fulmer 1989, Miller 1991, Hill 2002 and 2006). Such differences between the Hasa and its neighboring region may relate to the sensitive ecological conditions present in the former; its vulnerable and delicate ecosystem cannot sustain aggregates of tribal groups with long-term intensive mode of production (i.e., agropastoralism) in a progressively more arid climate (Hill 2006: 141, Figure 6.14).

Subsequently, the archaeological record clearly signals a dramatic change in the settlement systems of the Hasa from the Early Bronze to the Iron-II phase; 700% increase in the number of sites from Late Bronze (14) to Iron-II (112), with 39 Iron-I sites in between (Hill 2006: 43-47). I investigate whether the major contributing factors for such increase in settlements include the rise of territorial states of Edom (south) and Moab (north). The establishment of the King's Highway, a spice trade route connecting the Arabian Peninsula with the Eastern Mediterranean coast passed by the Hasa near As Safi. The revival of settlement came under new socio-political conditions, and although the modern climate (i.e., warm and dry) was already established, which would have made agriculture more limited in scale, both nomadic pastoralism (i.e., goat herding) and the caravan trade might have been the livelihood of the inhabitants of the Hasa in addition to its peripheralization by the Moabites. This fits well with Hill's suggestions about the late Iron Age environmental degradation of the Hasa, which leads to settlement decline in the Hellenistic period until the Nabatean revival in the region.

This chapter provided a detailed outline of how perceptions on the abandonment in archaeological context changed through time and came to be viewed as a deliberate action; a political and economic strategy to re-organize a society that is in search of a better direction for survival. The economic aspect of these decisions have been assessed in the context of Tainter's model while how these negotiations and social dynamics in tribal communities work have been discussed from the perspectives of dimorphic social structure and the heterarchy concept. As the re-organization requires new social formations, the issue of social change has been discussed in the context of scale free networks and scalar stress. Combining these approaches with Hill's research on the Hasa, I argued how the early metal age social change can be perceived in the subsistence strategies and settlement patterns. In the following chapter, I will present a detailed outline of the Holocene culture history and history of archaeological and paleoenvironmental research.

Chapter 3

THE HISTORY OF ARCHAEOLOGICAL AND PALAEOENVIRONMENTAL RESEARCH IN THE LEVANT AND TRANSJORDAN

The Geographic Locations

The onomastic term "Levant" refers to the land between the Jordan Rift Valley and the Mediterranean coast, which is bordered by the Anti-Lebanon mountain range in the north, the Syrian Desert in the northeast and the Negev Desert in the south. The region consists of the western mountains and the coastal plain. The Levant today, consists of the countries of Lebanon and Israel. The eastern side of the Jordan Rift Valley is known as the Eastern, or Transjordanian, Plateau; bordered by the Syro-Arabian Desert in the east and the Gulf of Aqaba in the south. Jordan covers majority of the area today.

The Paleolithic Prehistory in the Levant and Transjordanian Plateau

The Levant and Transjordanian Plateau are one of the earliest scenes of human habitation and wide ranging activities from hunting and gathering to advances in lithic technology throughout the Paleolithic, which started around 450 Kyr BP, in the southwest Asia. Towards the end of the Last Ice Age, series of major climatic changes took place. The EpiPaleolithic (20,000-10,300 BP) witnessed the transition from cool and dry glacial climate into warmer conditions, with a brief interruption between 11,500-10,500 BP (Olszewski 2001: 51). The warming trend in the climate was coupled with changes in fauna and flora and led to several important economic, technological and social adaptations among the hunter-gatherers in the region. These transformations are visible in the cultural sequence of Kebaran, Mushabian, Natufian, and Harifian (Bar-Yosef and

Meadow 1995: 53-61) in the Levant. The Natufian case usually stands out from the rest as their reduced mobility patterns suggest intensive and extensive wild cereal harvesting that possibly reached the level of intentional cultivation of wild species (Bar-Yosef and Meadow 1995: 67).

The Paleolithic is richly represented with many sites especially in the eastern half of the Hasa due to the presence of a pluvial lake (Olszewski 2001: 45). The combination of Mediterranean forest and open steppe environment of the west Hasa in the Middle Paleolithic (ca. 150,000-45,000 BP) changed into steppe by the Upper Paleolithic (ca. 45,000-20,000 BP) (Olszewski 2001: 39-42). As the climate became warmer, the lake in the east Hasa dried up and settlements mostly became short-term camps.

The Holocene Prehistory and Early History in the Levant and Transjordanian Plateau

The Pleistocene-Holocene (ca. 10,000 BC) transition ended with warmer and wetter climate that allowed expansion of forest systems as well as spread of other vegetation and animal communities. In the Levant and adjacent regions, the Holocene marked the beginning of the Neolithic (ca. 10,000-4,500 BC), which has two phases: the aceramic Neolithic (ca. 10,000-6,500 BC) and the ceramic Neolithic (6,500-4,500 BC). Building up on their experiences from the EpiPaleolithic period, the aceramic Neolithic groups domesticated certain plant (i.e., legumes and cereals) and animal species (i.e., primarily sheep and goats). They gradually became sedentary communities while also developing new lithic technologies and adjusting their social organization along with kinship and nuclear family under the new subsistence system, which is evident from the treatment of human remains (Rollefson 2001; Bar-Yosef and Meadow 1995). The sites of

Jericho and Ain Ghazal are clear examples of transformations summarized here (Rollefson 2001: 71, 73-74). Goats began to outnumber sheep towards the end of the aceramic Neolithic (Rollefson 2001: 81). It is important to emphasize however, that the reliance on wild resources is still significant and full-blown agriculture does not start until the next phase of the Neolithic (for the difference between domestication and agriculture, see Rindos 1980).

The ceramic Neolithic (ca. 6,500-4,500 BC) period represents both continuity and change from the previous period. The latter is evident in technology (e.g., ceramics), increased reliance on domesticates –as domestication becomes agriculture (see Rindos 1980)– and social organization (i.e., emergence of larger settlements) (Rollefson 2001: 91-92). The archaeological data suggest that during the ceramic Neolithic, the regional differences become more apparent in subsistence patterns and social organization. Based on the material culture, such as architecture, it is possible to identify three separate but interacting zones: the northern Jordan River Valley group, the Southern Jordan River Valley group and the eastern desert group (Rollefson 2001: 97). The archaeological record of the Hasa suggests a significant drop in the settlement density during this period, in comparison with the Paleolithic period. There are few sites in the west Hasa or the North Bank Survey area.

The Chalcolithic period (ca. 4,500-3,500 BC) in the Levant represents technological advancements, such as copper metallurgy, and diversification in subsistence patterns including the emergence of arboriculture (i.e., olives), specialized pastoralism, and especially the increased use of secondary products such as milk and

wool (Bourke 2001). Sites like Tulaylat al-Ghassul and in the Wadi Faynan reflect characteristics of the Chalcolithic culture in the region, in terms of their subsistence, standardized rectilinear architecture with 'broad-room plan' (i.e., the entrance to the room is from one of the longer sides of the rectangle), the use of copper technology especially for objects of ideological significance and structures that might have functioned as temples (Bourke 2001: 110-120).

During the Chalcolithic period the valleys are settled by large settlements and smaller sites are found on the piedmonts surrounding them (Bourke 2001: 113-115). Consequently, this is the first period when human habitation extends into environmentally marginal and geologically less stable areas (Bourke 2001: 109-110). However, the Chalcolithic settlements do not show specialized subsistence according to zones in the landscape. The only exception to this is the upland and marginal sites, which are thought to be pastoralist camps due to their unusually small sizes (Bourke 2001: 114). The generalized characteristics of most Chalcolithic sites reflect a mixed economy, which consisted of farming, horticulture and herding (i.e., sheep and goats). Additionally, a pastoralist subsistence pattern emerges for the first time as a strategy to survive on environmentally marginal lands in the region. This period does not represent a major change in the Hasa, in terms of settlement density; the number of sites remains low and majority of sites are in the eastern Hasa.

The nature of transition from the Chalcolithic into the Early Bronze Age (phases I-III, ca. 3,500-2,350 BC) has been widely debated; one group of scholars suggests continuity and explains the Early Bronze urban formations as a result of accumulation of

wealth and emergence of social differentiation on the basis of the intensification of Chalcolithic subsistence patterns. On the other hand, another group of scholars subscribe to the idea that the end of the Chalcolithic is marked by conflicts among groups that competed for more resources to produce surplus and generate wealth. This group perceives the Early Bronze urban formations separate from the previous period's social and economic achievements (Bourke 2001: Philip 2001).

The Early Bronze Age has traditionally been associated with the emergence of cities (e.g., Ur, Ebla) and the first state formations in Mesopotamia (i.e., Sumerian, Akkadian). This is the period when the southern Mesopotamian cities expanded their political and economic influence into the north, controlling resources and socio-economic life (Stein 1994 and 1999). In the Levant, however, both the nature (i.e., autochthonous or external) and the extent (i.e., regional or limited to the coastal areas) of the Early Bronze urbanization have been debated (Esse 1991, Dever 1989, Falconer and Savage 1995, Finkelstein 1995). Currently, a group of scholars (Philip 2001; Chesson 2003) propose that based on the low population density, lack of institutionalized elites and the absence of large sites similar to the ones in Mesopotamia, the emergent social complexity should be evaluated within the heterarchy concept, which is discussed in the previous chapter.

The Early Bronze Age witnessed the establishment of complex irrigation systems across the Southwest Asia. Additionally, terrace agriculture originated in this period (Philip 2001: 184-187). These indicate the intensification of subsistence practices during this period. Pastoralism and arboriculture also continue, albeit at a larger scale than the Chalcolithic period (Philip 2001: 187).

Based on the changes in economic and other archaeological evidence (i.e., burials, architecture), the Early Bronze I-III phase seems to be a time when social differentiation becomes more visible, and different groups (i.e., pastoralists and agriculturalists) selectively settle on the landscape (i.e., highlands vs. lowlands) in symbiotic relationships. It is also suggested that corporate power strategies emerge within heterarchic social organization to protect interests of various groups in the society (Philip 2001; Chesson 2003). These define the fluid political dynamics of the region during the later prehistory.

On the Transjordanian Plateau, except for few areas, the settlements are spread across the landscape. One of the few places where settlements are concentrated is the Karak Plateau, which borders with the Hasa on the north. The Karak has a high site density during the Early Bronze I-III and habitation continues throughout the late Early Bronze (Philip 2001: 193), as discussed below. The Hasa witnesses a significant increase in settlement activity since the Paleolithic period. Although the sites are considerably smaller than their counterparts in the north and west (Philip 2001: 194), they show more balanced distribution across the drainage.

The last phase of the Early Bronze, Early Bronze IV (ca. 2,350-2,000 BC), shows major changes in terms of social organization and subsistence patterns. Although this is a phase that is only valid for Levantine archaeology, it is contemporaneous with sociopolitical and economic crises in the Levant and elsewhere (e.g., Mesopotamia and Egypt). There is ongoing debate about the reasons for the large-scale collapse of social complexity in the Southwest Asia at this time, emphasizing either environmental or
political aspects (Dalfes, Kukla and Weiss 1998; Yoffee 2006). Political decentralization, decline in economic specialization, and social conflicts in this phase have long been associated with the rift between the rural and urban sectors of the Mesopotamian society (Liverani 1987: 69-70). These changes in socio-economic complexity, evident from settlement patterns, show small sites across the landscape without any sign of population aggregation. They also include weakening of long-distance trade relationships, which, in previous phases of the Early Bronze had grown extensively –even reached to the level of colonization (Stein 1999). The subsistence system in this phase remains differentiated into nomadic pastoralists and sedentary agriculturalists (Nichols and Weber 2006: 45-46). Although these groups have a symbiotic relationship, nomadism especially allows for more flexible and resilient socio-economic strategies at times of hardship such as the late Early Bronze Age. The Early Bronze IV brings large-scale abandonment of sites and depopulation across the Levant, including the Hasa (Palumbo 2001: 236-240). The continuing sites in the north and central-south Jordan, on the other hand are characterized by sedentary agriculture (e.g., Tell el-Hayyat and Tell Abu en Ni'aj, Falconer 1987 and 1995). The nature of occupation at other sites has been studied by scholars, mostly from the perspective of ceramic evidence (Dever 1985 and 1987).

The overwhelming scale of abandonment in the Levant and resultant dispersed settlement patterns of this period have been used to indicate social change. According to many scholars, this phase brings an end to the highly specialized economic organization of the Early Bronze I-III. Under various sources of stress (i.e., environmental, political), society attempts to survive by diversifying subsistence patterns within a dimorphic social structure (Marfoe 1979; Palumbo 2001; Nichols and Weber 2006). Consequently, the settlements of this period are much smaller and have mainly rural character. This change is observed in the Hasa at a much larger scale. This phase represents the beginning of a very long period of abandonment, until the beginning of the Iron Age (ca. 700 BC).

The Middle Bronze Age (ca. 2,000-1,500 BC) is viewed as a period of urban revival in Mesopotamia (Nichols and Weber 2006: 54-57) and in the Levant (Falconer 2001: 271). The revival of the Mesopotamian urbanization is usually related to the dense population, integration of economically diverse groups, and the exploitation of previous trade connections, which transform small-scale producers of the previous phase into active participants in a new urban system, which is based on kinship and aggregation of diverse polities (Nichols and Weber 2006: 55, 57). In Transjordan, the revival is obvious from the settlement patterns (i.e., return of settlement hierarchy) on the north and central plateaus. On the Levantine coast, the recovery of urban systems is much faster and more obvious than the interior (Falconer 2001: 276). Southern Levant, on the other hand, shows a different trend in which site density increases but the site size drops. These results suggest that following the late Early Bronze disintegration, the social, economic and political revival is slow and communities continue to remain largely rural (Falconer 2001: 281-283). The settlement patterns on the Transjordanian Plateau mirror these observations; the settlement density is only half as much on the Karak Plateau whereas the Hasa remains almost unoccupied. The Middle Bronze Age in the Levant is especially important from the perspective of the human impacts on the landscape. The subsistence pattern of this period relies heavily on arboriculture (i.e., olives, grape, figs) (Falconer

2001: 274). Based on the archaeological and proxy data, such as palynology, it is clear that the intensive arboricultural activities of this period lead to significant deforestation (Falconer 2001: 275). Seasonal pastoralism complemented arboriculture and farming.

The Late Bronze Age (ca. 1,500-1,200 BC) is less well-known period in the Levant due to lack of published results of research. This period is characterized by the Egyptian invasion and occupation of the greater portion of the Levant (Strange 2001: 292). The settlement patterns of the period suggest that people avoided marginal lands possibly due to increased aridity that is evident from the paleoenvironmental record of the region (Strange 2001: 293). Late Bronze Age settlements are found usually in the western and northern areas of the Levant. Settlement activity declines on the Transjordanian Plateau in comparison with the previous period (Strange 2001: 297). Settlement patterns also suggest that pastoralist groups frequented the areas where settlement activity is low, while cities continued from the previous periods in other parts of the Levant under Egyptian control (Strange 2001: 304). The subsistence of this period shows same characteristics as the previous period. However, much produce may have been given to the Egyptian vassals as tribute (Strange 2001: 306). The Hasa continues to show very low settlement activity in this period.

The Iron Age (ca. 1,200-500 BC) represents the emergence of territorial states in the Levant. On the Levantine coast, the state formation is initially observed in the north and south (i.e., Israelite and Judea); Saul unified them and under David the Israelites became a state in early 9th century BC (Finkelstein 1989 and 1999). Following statehood, socio-economic changes occur; administration centers emerge across the Levantine coast,

fortified settlements increase in number, a settlement hierarchy emerges, public and ideological architecture becomes more obvious in the archaeological record, and the significance of crafts in economy increases (Dever 1995; Finkelstein 1999).

The socio-political and economic transformations on the Levantine coast contribute to social and political change on the Transjordanian Plateau. Here, the tribal states of Ammon (near Amman), Moab (on the Karak Plateau), and Edom (on the Edom Plateau) emerge (LaBianca and Younker 1995: 400-402). These tribal states have been defined as political entities where tribal identity has significance, they lack economic specialization, and the settlement systems are composed of self-sufficient sites with minimal settlement hierarchy (LaBianca and Younker 1995; LaBianca 1999). On the Transjordanian Plateau, settlements gradually spread towards the south (Herr and Najjar 2001: 323). The development of the settlement systems in this period can partially be attributed to the emergent trade relationships, such as the Arabian caravan trade (Herr and Najjar 2001: 325) –or the King's Highway (Herr and Najjar 2001: 337)– which follow a north-south route that bisects the Hasa. The densest settlement activities are initially observed in the north around Amman and Madaba, where settlements are fortified and examples of public and palatial architecture are recorded (Herr and Najjar 2001: 326-327). The spread of these settlements into the southern areas takes place around 900 BC on the Moab and Edom plateaus (Herr and Najjar 2001: 331). The settlement density in the Hasa significantly and suddenly increases in the Hasa during this period. The exact nature of this change in settlement systems have been related to the expansion of the

Moabite state on the Karak Plateau (MacDonald 2000; Bienkowski and van der Steen 2001; Hill 2004).

The Archaeological Research

Both the Levant and Transjordan show diverse climatic and environmental conditions, which will be discussed in detail in the following chapters. The rich paleoanthropological and archaeological heritage of the region is the result of such environmental diversity traits as well as its proximity to the Mesopotamia and its land bridge role between Africa and Asia.

<u>The First Steps:</u> The Levant and Transjordan have been the foci of intensive archaeological and anthropological research since the beginning of the 20th century in quest for the antiquity of humanity, which fed the intellectual interest towards the past cultures of the Southwest Asia in general, Mesopotamia and the Levant in particular. The pre-20th century pioneers were avid travelers, but lacked any detailed knowledge of the past cultures in the Levant or Transjordan.

<u>The First Systematic Excavations</u>: Between 1900 and 1920, the interest for the human heritage of the Levant and Transjordan grew immensely for two main reasons. Firstly, archaeology was becoming a serious and organized research field with its own methods, techniques and principles. Secondly, the political fragmentation of the Ottoman Empire and increased Western interests in the region allowed the British, Italian and American researchers to lead longer and more organized expeditions in different parts of the Levant and Transjordan.

Subsequent expeditions between 1919 and 1939 unearthed major mounds such as Tell Beit el-Mirsim, Tell Ajjul and Bab edh-Dhra, which revealed the complex nature of the end of the Early Bronze and the beginning of the Middle Bronze ages in the region. Early scholars identified this phase as either "Middle Bronze I" (Albright 1962) or "Early Bronze IV" (Wright 1975). The latter has become the conventional label for this period, which is traditionally dated between 2,300 and 2,000 B.C.

<u>Post-World War II Research</u>: Following the Second World War, the increased amount of archaeological research, the continuous development of archaeology as a discipline and the growing body of evidence not only contributed to better understanding of the past cultures but also allowed construction of various hypotheses to explain cultural changes reflected in the evidence (Hanbury-Tenison 1986; Palumbo 2001). This attempt to interpret archaeological evidence is the major difference between the earlier research and the research after 1950s.

Defining the Early Bronze IV Period, Collapse and Social Change: Kenyon proposed the theory of "Amorite Invasion" (1966) to explain the late Early Bronze destruction and widespread de-urbanization in Mesopotamia and the coastal Levant, and it remained widely accepted until 1980s. Amiran (1960) was the first scholar who identified significant regionalism in the past cultures of the Levant, based on ceramic assemblages (i.e., "Families"), and presented it as a cultural model for the Levant in the final quarter of the third millennium B.C. This approach shared with that of Cordell and Gummerman for the U.S. Southwest (1989: 1-17) an emphasis on increasing regionalism and social change, discussed in the preceding chapter.

Dever integrated Amiran's ceramic families into the "Dimorphic Society" concept of Marfoe (1979) to explain social change during the Early Bronze IV Levant. His "Pastoral Nomadic Model" (Dever 1980) emphasized a symbiotic relationship between the pastoralist and agriculturalist groups in which he proposed that society had become predominantly nomadic (i.e. transhumant pastoral) following the limited (i.e., in the coastal areas) urbanization during the Early Bronze II-III. Finkelstein developed the "Multimorphic/Polymorphic Social Structure" theory based on these approaches (1989 and 1995) emphasizing different subsistence patterns (e.g., pastoralism and farming) and associated unique social organizations in tribal groups.

Falconer's research in Early Bronze IV and Middle Bronze II, based on the excavations at Tell el Hayyat and Tell Abu en Ni'aj (1987 and 1995) showed that the pastoral rural base in the Levant had become an integral part of the urban system in times of political stability but acted independently during times of political or economic crisis (Falconer 1995: 401).

Richard, using an earlier study of Lees and Bates (1974), proposed that the social and economic shifts throughout the Early Bronze occurred due to changes in the nature of production in the Levantine society. The highly specialized production system and interregional exchange for wide variety of goods and items that characterized the Early Bronze II-III gave way to an economic system, which consisted largely of de-specialized production, low level of inter-regional contact and self-sufficient communities by the Early Bronze IV (Richard 1980, 1987; Palumbo 2001). This aspect of change in the economic organization is discussed in detail under Tainter's Economic Model in the previous chapter.

As a reaction to the linear models mentioned above, Palumbo (1991 and 2001) developed an approach, which characterized changes in subsistence patterns as adaptive strategies. The Levantine society adjusted the level of production and type of subsistence (i.e., agriculture, pastoralism) depending on wide variety of environmental, economic, political and social factors (2001: 259). Under favorable climatic conditions, such as predictable and sufficient rainfall, the society opted for specialized production and greater integration of communities, which led to urban formations in certain areas and higher social complexity (Palumbo 1991: 131-134). During the times of social, political or environmental crisis (i.e., land degradation, drought) the process was reversed and the society moved back to the pre-urban stages of socio-economic organization; selfsufficient and self-sustaining production, highly mobile tribal groups (Palumbo 1991: 129). The rural sector was deemed to be highly resilient and eventually acted as the ultimate survival factor at this point (Palumbo 1991: 134). Detailed ethnographic research on the pastoral communities of the region provided further support to the cycles of intensification and abatement in relation with political and economic factors. The crystallization of these approaches is observed in researches and publications of LaBianca (1990), Chesson (2003) and Greenberg (2003a, 2003b), which is discussed in detail in the Theory chapter.

<u>Archaeological Investigations in the Wadi el-Hasa</u>: The Wadi el-Hasa is the principle valley in west-central Jordan, located between Amman and Aqaba, and is also the only permanent water drainage between the Syro-Arabian Desert and the Dead Sea Rift Desert (Harlan 1988: 40).

The first modern references to the Hasa are found in traveler logs from the 19th century, mainly noting its grassland environment. Glueck, who was conducting surveys for the American School of Oriental Research between 1934 and 1940, was the first to mention the archaeological potential of the Hasa, (MacDonald 1998: 29). Bennett mentioned the drainage while exploring the 8th century B.C. remains in the Tafila-Busayra region, to the south (MacDonald 1998: 31).

In 1979, MacDonald conducted multi-disciplinary survey over much of the Hasa, with the exception of the northeast plateau (i.e., the North Bank). MacDonald's research specifically focused on the prehistoric periods between the Epi-Palaeolithic and Chalcolithic periods (ca. 12-5 Kyr B.P.) (MacDonald 1988) and the results indicated heavy settlement and human activity. Clark's North Bank survey, in early 1990s, revealed that the Hasa also had dense human occupation and witnessed variety of activities from the Middle Palaeolithic to the Epi-Palaeolithic (ca. 70-12 Kyr B.P.) (Clark et al. 1988 and 1998). Based on this research, "The Hasa Model" (Olszewski and Coinman 1998; Schuldenrein and Clark 2001; Schuldenrein and Clark 2003) was developed to explain the Late Pleistocene (ca. 25-11 Kyr B.P.) human adaptations in the region. This has become an important model for Pleistocene settlement along with the models of Henry (1988 and 1995) and Marks & Friedel (1977).

The most recent research on the archaeology of the Hasa is in the form of dissertations and theses that use and supplement the data from the earlier large-scale surveys. Coinman (1990) did a comparative study of the Upper Paleolithic lithic assemblages to contextualize the changes in the southern Levantine tool industry. Neeley (1997) focused his research on the late Pleistocene - early Holocene chipped stone assemblage and settlement patterns in the Hasa. Papalas (1997) studied the Chalcolithic and the Early Bronze Age architectural forms. Davies (2000) did a comprehensive paleoenvironmental reconstruction of the Jordan Plateau, using the lacustrine deposits, and also evaluated the Hasa Pleistocene sediments. Al-Nahar (2000) focused on the upper and EpiPaleolithic transition in the southern Levant and studied the microlithis from the Hasa sites. The most comprehensive study of the ancient Hasa is Hill's research on the geomorphology and the archaeology of the Wadi. It focused on the ways in which changing geology of the drainage basin affected the social, economic and political organization of people, from the Neolithic to the Ottoman period (A.D. 1914). Combining geographical information systems (GIS) with the traditional methods of archaeology, Hill (2002, 2006) also addressed anthropogenic impacts on the fragile ecosystemic balance of the Hasa.

Palaeoenvironmental Research

<u>Why Study the Paleoenvironments:</u> In any study of prehistoric social and economic organization, the natural setting of culture is of course significant. Knowledge of environment is necessary for understanding for enabling researchers to observe the natural context of adaptive behaviors. Therefore, archaeology uses a wide variety of

methods such as palynology and geomorphology in order to reconstruct climate and environment in prehistory.

Paleoenvironmental reconstructions, when combined with the archaeological evidence, bring wider perspective to the interpretation of the cumulative data, which then allow for detailed analyses of differential human behavior, cultural adaptations, and illustrating the dynamic relationship between the culture, its environment, and anthropogenic impacts on environments through time.

Limitations: Although there are various methods of reconstructing the paleoenvironment reconstructions and each serve a unique purpose, they all use proxy data (i.e., pollen cores, sediment samples) for past environmental and climatic conditions. Proxy data can only inform us about past environments indirectly. The links between proxy data and environmental phenomena sometimes are not well understood, and proxy data themselves are often largely incomplete due to natural and cultural formation processes (Schiffer 1987). Consequently, the interpretations based on such evidence must be cautious and they must be up-dated with the most recent archaeological evidence and other palaeoenvironmental data available.

<u>The History of Palaeoenvironmental Research in the Levant and Transjordan:</u> The Levant and Transjordan are at the intersection of the Mediterranean, semi-arid, and arid climatic zones. Considering the antiquity of human activities in these regions, paleoenvironmental research offers a potential to better understand how environmental factors affected the human socio-economic adaptations through the ages.

Paleoclimate While the research on the past climates relies on the use wide variety of proxy data, the summary of paleoclimatic research in the Levant provided here focuses on the use of speleothems, paleogeomorphology, palaeolimnology and palynology. Each category is described briefly and the most significant research results are presented to provide an overview of the past climatic conditions in the research area as indicated by various sources of data.

The term speleothems refers to secondary mineral deposits formed in limestone or dolostone solutional caves such as stalagmites and stalactites (Bar-Matthews, Ayalon and Kaufman 1997: 155). These geological formations are reliable but complicated indicators of past climatic conditions since these formations grow by adding layers, and each layer contains chemical composition of the groundwater, which reflects changes in precipitation, temperature and humidity over time (Bar-Matthews, Ayalon and Kaufman 1997: 161). Temporal shifts in climate are illustrated by the changing ratio of stable isotopes of Carbon-13 to Oxygen-18 from samples (Bar-Matthews et al. 1999: 87-89). Oxygen-18 peaks occur during phases of extreme cooling (i.e., reduced foraminifera and planktons) whereas warming trends cause a drop in Oxygen-18 due to melting of ice sheets and the increased amount of water in the ecosystem. During phases of increased precipitation, the Carbon-13 fraction is higher due to high water table and lake levels, which contribute to increased sapropel formations (i.e., dark-colored sediments that are rich in organic matter and result of reduced oxygen availability due to reduced deep water circulation) (Bar-Matthews et al. 1999: 90).

Although scholars conducted extensive research of sapropels in caves, the accidental discovery of Soreq Cave in Israel (about 60 km. inland from the coast) in 1968 changed the direction of speleothems-based climatic research. Bar-Matthews and others have identified regional scale climatic phases for the last 60,000 years using data from Soreq Cave (Bar-Matthews, Ayalon and Kaufman 1997; Bar-Matthews et al. 1999; Bar-Matthews, Ayalon and Kaufman 2000), with a higher temporal resolution for the last 25,000 years (Bar-Matthews et al. 1999: 89-92). The first major change in the data took place between 17,000 and 15,000 BP, when climate turned into warmer and wetter (Bar-Matthews, Ayalon and Kaufman 1997:161-162). Before this phase (25,000-17,000 BP) and after (15,000-10,000 BP), the ratio of Oxygen-18 to Carbon-13 indicated persistently dry conditions, with a peak that corresponds to the Younger Dryas ca. 12,000-10,000 BP. (Bar-Matthews, Ayalon and Kaufman 1997: 165). There were two brief episodes of wetter climatic phases after 10,000 BP (Bar-Matthews, Ayalon and Kaufman 1997: 165). The timing of these changes was also supported by increased levels of the Dead Sea and lakes in Africa as well as Arabian Peninsula (Bar-Matthews, Ayalon and Kaufman 1997; Bar-Matthews et al. 1999). The sapropel data indicated the establishment of the current climatic conditions in the region (i.e., dry and warm) ca. 7,000 BP (Bar-Matthews et al. 1999).

The use of paleogeomorphology, especially the study of the late Quaternary alluvial geochronology, is a second source of proxy data for the past climatic research. In the southern Levant, the more recent research of this kind has been building on the classic study of Vita-Finzi (1966 and 1969), as discussed in detail below. Mabry (1992)

especially focused on the late Quaternary cycles of aggradation and erosion in the region as his dissertation research and attempted to correlate some of the events in the geological record to changing climatic patterns. The results of his research indicated at least eight major alluvial cycles during the last 75,000 years (Mabry 1992: 135). The complex sedimentary record of the region for the last ice age revealed a climate of cold and dry (i.e., colluvial deposits, erosion and river down cutting) that was punctuated by episodes of wetter or drier conditions (Mabry 1992: 136). The signs of rapid aggradation, high stream discharge and the presence of sites on alluvial fill suggested a major shift in climate towards wetter and warmer during the early Holocene (around the pre-pottery Neolithic). This mesic episode was interrupted by a dry phase at the beginning of Chalcolithic period and became wetter again throughout the Early Bronze Age (Mabry 1992: 136-138).

The result of Mabry's research agrees well with site-specific paleogeomorphologic research at Wadi Faynan in southern Jordan by McLaren and others (2004). Researchers studied the sediments from wadis Dana and Ghuweir in order to observe possible impacts of climatic changes on the geological record. The research relied on identifying the type of environment that was responsible for the emergence of the geological record: erosion, aggradation, channeling or size-sorting. The results showed during the early and mid-Pleistocene the drier conditions initiated erosion in the mountains and deposition in the lowlands, hence forming fans and fluvial deposits (McLaren et al. 2004: 151). Following the Late Glacial Maximum, ca. 23.000-15.000 BP, the Aeolian deposits were deflated, which pointed to persistent arid conditions in the

region (McLaren et al. 2004: 150). The wetter conditions brought by the Holocene transition were evident in the perennial river deposits as well as deposition of alluvial fans, although it was more complicated to identify the exact reasons for changes in sedimentary environment due to increased anthropogenic activity in the region (McLaren et al. 2004: 151).

The use of palaeolimnology: the study of past changes in lake levels, has made significant contributions to the study of past climates. In the Levant, such research focused especially on the levels of the Dead Sea (Frumkin 1997; Bowman 1997). Many researchers have discussed the complex geological history of the Dead Sea. Bowman provided a comprehensive discussion of how its lacustrine predecessor, Lake Lisan (ca. 50,000-12,000 BP), was formed and correlated the changes in levels of Lisan to climatic and tectonic events during the Pleistocene (1997: 217-221). The Dead Sea has been a significant source of information in past climate research because it is a pool for rivers around it, and any change in water table due to climatic or other reasons is registered in the Dead Sea. The alluvial fans around the Dead Sea itself more directly show the responses of lake level to climatic change (Bowman 1997: 222). Frumkin conducted a detailed study of the Dead Sea levels using the sedimentary record, especially marls (calcium carbonate rich sediment indicating lacustrine conditions) and lake shore terraces, identifying marls that dated to the late Pleistocene (i.e., Lisan phase), when the levels were significantly higher (1997: 241). The data suggested that Lisan went into a drying phase around 14,000 BP and almost completely dried out around the Holocene transition (Frumkin 1997: 241) when the Dead Sea was 400 meters below its modern

level (Frumkin 1997: 243). This drying phase corresponded to the generally cooler and drier climate that characterized this period. The lake level began to rise after Holocene transition, due to availability of more water in the region as a result of improved precipitation. This high stand formed terraces around the shores of the Dead Sea and continued until ca. 4,000 BP with several brief interruptions around the end of the late pre-pottery Neolithic and early Chalcolithic (Frumkin 1997: 244-245). Donahue, Peer and Schaub (1997) used similar data and correlated them with the archaeological evidence from some of the major Early Bronze sites from southern Jordan such as Bab edh-Dhra and Numeira. Comparing the Early Bronze settlement systems with the later periods, researchers were able to illustrate how ancient inhabitants of the region responded to changes in the level of the Dead Sea. The densest settlement activity around the Dead Sea took place during the Early Bronze, when the lake levels were at its highest during the Holocene and terraces were formed on the shores of the Dead Sea (Donahue, Peer and Schaub 1997: 134-135).

Palynology The significance of palynology for past environmental reconstruction and especially for understanding of past plant communities, is discussed below. Palynology also contributed to the study of past climates in a more indirect way: the assessment of climatic conditions through the reconstructed plant communities and their known environmental requirements. Horowitz conducted intensive palynological research in the Levant; collecting samples from the Dead Sea, lakes of Kinneret and Hula and used these data to construct a detailed climatic reconstruction of the region going back to 150,000 BP (1989: 66-71). He identified three phases of climates during the Quaternary, based on the pollen evidence: the *Interstadial*, which was the Mediterranean climate phase with low arboreal composition of flora (Horowitz 1989: 72-73). *Interpluvial* signified the desert-like climate with extremely low arboreal composition, suggesting very low precipitation (Horowitz 1989:73). *Pluvial* phase indicated a phase when precipitation was higher under Mediterranean climate and pedogenic processes were observed in loess formations and an increase in arboreal pollens, especially oak was significant (Horowitz 1989: 73). Based on these reconstructions, Horowitz argued that the global climatic belts moved north during Interpluvial phase and brought the Levant into the Saharan high pressure system whereas during the pluvial phase the belt shifted to south and led to increased precipitation due to the westerlies (Horowitz 1989: 75).

Horowitz (1971, 1974) used cores from Hula (K-Jam, U.P. 6 and U.P. 15) and Kinneret (D-1016/2) basins to correlate the Levant with the Mediterranean Basin and continental Europe in terms of environmental conditions. Two major climatic phases emerged from Horowitz's data, the more humid (i.e. the Atlantic) phase with arboreal pollen dominating the spectra corresponded to the Early (ca. 3,500-2,400/2,300 B.C.) and Middle Bronze (ca. 2,000-1,100 B.C.) urbanization in the region (Horowitz 1974: 408). The dry (i.e. the Sub-Atlantic) phase was dominated by non-arboreal species in the pollen record and was contemporaneous with non-urban societies between ca. 2,250 B.C. and 2,000 B.C., and then after ca. 950 B.C. (Horowitz 1974: 413). This research provided the first palynological evidence for late third millennium B.C. climatic oscillations which might have contributed to the collapse of the Early Bronze II-III urban system in the Early Bronze IV in the Near East.

Horowitz has recently studied the pollen records of the Jordan Rift Valley, using the cores taken from the west side of the Valley, which he organized into ten zones (Horowitz 2001). The tenth zone, Q-10 corresponded to the Holocene from 11 Kyr to present. The climate was humid at the beginning, but became warmer and drier after 5,000-4,500 B.P. This warm, dry interval roughly corresponded to the Early Bronze IV (Horowitz 2001: 612).

Baruch (1990) compiled the palynological record of the Dead Sea with results parallel to the Kinneret data mentioned above (Baruch 1990: 287-288). His research was significance because the data also bore the earliest signs of anthropogenic impacts (i.e., of especially horticulture and grazing) on the environment during the late Neolithic. These gradually intensified through the Chalcolithic and the Early Bronze, and eventually led to the degradation of forests, which started severe erosion due to cultivation, grazing and burning especially during the third and second millennia B.C. (Baruch 1990: 292).

Geology/Geoarchaeology In the northern Levant, Vita-Finzi studied sediments broadly across the eastern Mediterranean, where he identified changes in fluvial processes (i.e., aggradation and incision) throughout the Pleistocene and Holocene (1969). With Copeland, Vita-Finzi studied the geological deposits in Jordan and dated them with the help of archaeological sites (1978). They identified several cycles of aggradation that formed terraces (i.e., "Fills"). The Fill I, "Tabaqa Formation" in the Hasa, was the result of the late Pleistocene aggradation, which continued until around the beginning of the Holocene (Hill 2006: 78). Most late prehistoric sites, in addition to late Pleistocene (i.e., Natufian) camps are found on this terrace (Hill 2006: 78). Fill II of Copeland and Vita-Finzi was also known as the "Lower Terrace", whose extent is unclear in the Hasa. Based on the archaeological evidence from other valleys around the Hasa, this terrace was the result of early Holocene aggradation (Hill 2006: 79). The Hasa witnessed another aggradation phase in the Early Bronze Age, until the beginning of the Early Bronze IV incision. The aggradation cycle between the middle and late Holocene formed Fill III (the "Hasa Terrace"), which ended around the time of the Nabataean occupation (ca. 312 BC). The results of Copeland and Vita-Finzi's research for the Holocene fluvial history of the region can, then be summarized for the Hasa as follows: the Tabaqa formation that accumulated in the late Pleistocene underwent gradual but significant incision during the earlier half of the Holocene. Subsequently, and while there were intermittent aggradation phases, the scale of channel cutting increased around the Early Bronze IV and continued into the Iron Age (Hill 2006: 81)

Neev and Emery (1967) conducted geological research in the Dead Sea and discussed the depression, fault lines, the physical structure of basins, sediment types and stratigraphy, ancient shorelines, and chemical characteristic of the Dead Sea water at great length.

Frumkin, whose research was described previously, identified three major cycles of lake level changes between 10,000 and 2,300 B.C. based on salt layers (i.e., low levels), marls (i.e., high levels) and cycles of alluviation and aggradation (1997: 241-245). Correlating these data with pollen spectra and sediments characteristics, he showed that continuous rise in the Dead Sea level and accompanying sediment aggradation were associated with a relatively moister period between 3,500-2,300 B.C. (Frumkin 1997:

242). Major down cutting, erosion and degradation were observed after 2,300 B.C., coupled with lower lake levels. These data were used to propose a major drought in the Levant and also to support environmentally driven explanations of Early Bronze IV collapse in the Levant and Transjordan.

Donahue (1985) studied pre-cultural stratigraphy and topography of Bab edh-Dhra and Numeira. Recent research at major Early Bronze settlements such as these showed consistent patterns of erosion after the Chalcolithic, a period when the Dead Sea levels dropped due to warmer and drier climate (increased evaporation), and river down cutting (Donahue, Peer and Schaub 1997: 131). It also has become clear that settlement patterns around the Dead Sea followed the migrating shorelines as lake levels changed (Donahue Peer and Schaub 1997: 133-134).

The first geoarchaeological research on the west side of the Rift Valley was conducted by Horowitz (1979), who focused on regional geomorphology, tectonics, fluvial regimes, sediments, erosion/deposition cycles and the corresponding climatic conditions. More recently, Horowitz has focused on the geomorphology of the Rift Valley (2001), using geological, palaeolimnological, palynological and geophysical data to construct the Quaternary chronostratigraphy of the area. Regional stratigraphy was dated through correlation of the pollen data. The wetter conditions at the beginning of the most recent climatic phase (Zone Q-10) allowed terrace (i.e. the Tabgha) formation, associated with lush vegetation, expansion of lakes and an increase in number of settlements (Horowitz 2001: 612). However, the climate became warmer and drier after ca. 5,000-4,500 B.P. (i.e., Early Bronze IV period) leading to erosion and drying up or

shrinkage of lakes (Horowitz 2001: 612-614). This climate change also affected the settlement patterns. Although sites near major drainages and lakes (i.e. the Jordan Valley sites) survived, those in more marginal zones (in terms of vegetation, soil type and distance to water source), like most of the Hasa, seemed to be deserted at this time (Horowitz 2001: 614).

Bar-Matthews and others studied oxygen and carbon isotope ratios in dolomites, to identify regional climatic variations (i.e., wet or dry phase) (1999: 86) in Soreq Cave, located in the transitional zone from the humid climate of the northern Israel to the arid climate of the south. The results showed unusually wet periods between 8.5-7 Kyr B.P. After 7 Kyr B.P. however, isotope ratios came close to the modern day levels (Bar-Matthews et al. 1999: 91).

In the southern Levant, Goldberg identified several cycles of erosion/redeposition related to dry/wet periods by studying the kurkar (i.e., eoliantie) formations in the coastal zone of the southern Levant (1986: 227, 230, 233, 236 and Figures 3, 4, 6-8). Subsequently, he dated all of the kurkar formations within the general climatic framework of the southern Levant since 90 Kyr B.P. (Goldberg 1986: Figure 9). In his synthesis, Goldberg stressed the complex relationship between climate changes (i.e., both long and short-term) and aggradation/erosion cycles. This dynamic relationship became even more complicated when human impacts emerged (in different intensity at different areas of the southern Levant) emerged (Goldberg 1986: 237-242). Goldberg and Bar-Yosef (1990) also put major southern Levantine prehistoric settlements, such as Tell Lachish, Salibiya, N. Resisim and N. Issaron, into regional context for geomorphological processes and associated paleoenvironmental events. Their research revealed further evidence for more humid climate during the late Chalcolithic and the earlier part of the Early Bronze (Goldberg and Bar-Yosef 1990: 74-75, 77). The rise of social complexity and urbanism in the coastal Levant was partially attributed to improved humidity. Intensive human impacts and climatic deterioration (i.e. warmer and drier) are thought to be the main factors in the collapse of complex social systems at the end of the Early Bronze (Goldberg and Bar-Yosef 1990: 83-84).

McLaren and others (2004) reconstructed geological evolution of Wadi Faynan from 80 Kyr B.P. onwards. Major changes to the geomorphic structure and deposition of sediments in the Wadi during the Holocene were related to climatic changes (McLaren et al 2004: 134-135). The research on the early Holocene fluvial deposits (including pollen, micro- and macro-fossils) of the Wadi indicated that the early Holocene environment was composed of diverse forest vegetation with perennial streams. However, changes in the climate after the Neolithic, along with increased frequency and density of anthropogenic impacts (i.e., especially intensive grazing) starting with the Chalcolithic, caused not only the replacement of this vegetation by steppic flora but also increased aggradation in adjacent wadi systems, transforming some river systems (i.e. Ghuweir) to braided channels (Hunt et al. 2004: 940-941). Barker and others studied Wadi Faynan sediments to understand the geologic evolution of the area, how humans adapted to the desert landscape, and the types of changes that emerged on the landscape due to human activities. The research showed that Faynan area had very rich and diverse resources as late as 6th-5th millennia B.C., but subsequently became a desert landscape due to tectonic events, intensive land-use patterns, systematic copper mining, and changes in the fluvial regime due to aridity that started incision and erosion (Barker et alii. 1997: 33-35; 1998: 6-9).

Mabry (1992) conducted the most detailed geoarchaeological research in the southern extremity of the Jordan Valley, focusing on the alluvial cycles during the late Quaternary and dating each cycle by variety of methods. He contextualized the climate, vegetation, and sediment characteristics of southern Jordan within the southern Levant. The Holocene climate was initially warmer and moister, Mediterranean woodland and Irano-Turanian steppe expanded (Mabry 1992: 139). Flood deposits laid down bettersorted, finer grained sands, silts and clays integrated with brief episodes of erosion (Mabry 1992: 137). As the Holocene climate became warmer and drier (especially during the Holocene Climatic Optimum, ca. 7-5.5 Kyr B.P.), the frequency of erosional cycles increased and became longer. This was concurrent with increasing human activities and tectonic events in the Levant and the Jordan Valley (Mabry 1992: 138). According to Mabry, late Holocene erosion was initiated by a combination of climatic (i.e., drought) and anthropogenic (e.g., land degradation) factors (Mabry 1992: 18, 20).

In the Hasa, the geological research began with Willimott's survey (1963) for oil exploration purposes. Copeland and Vita-Finzi studied the sediments and alluvial fills of the Hasa, identifying four major alluvial fills: from the early Upper Palaeolithic (Fill I),

pre-Kebaran Upper Palaeolithic (Fill II), Kebaran (Fill III) and Historical (Fill IV) periods (1978: 12), each with features characteristic of different depositional conditions.

Schuldenrein and Clark (2001, 2003) conducted detailed geoarchaeological and geomorphological survey of the Hasa in order to create a model for prehistoric human palaeoecology. The study combined settlement patterns with the paleoclimatic and geomorphological record of the Hasa. According to their reconstruction, the "High Terrace" indicated high-energy fluvial systems of the Upper Palaeolithic and high levels of Lake Hasa in the eastern part of the Wadi (Schuldenrein and Clark 2001: 30). The beginning of warmer climate and desiccation switched aggradation to incision ca. 20 Kyr B.P. (Schuldenrein and Clark 2001: 31). Wetter and moister conditions were reestablished in the Wadi el-Hasa by 17 Kyr B.P. as evident from alluviation and the formation of the "Middle Terrace" with mesic flora (Schuldenrein and Clark 2001: 32). The significant aridity that affected the Levant at the end of the Younger Dryas, ca. 12-10 Kyr B.P. caused incision in the Wadi (Schuldenrein and Clark 2001: 32). The "Lower Terrace" was formed at the beginning of the Holocene (i.e. the Pre-Pottery Neolithic period), associated with regional pollen records, flourishing settlements, and rich aquatic flora in the Wadi el-Hasa suggesting wetter and moister climate (Schuldenrein and Clark 2001: 32). In the Hasa, the Chalcolithic sites were located on this alluvial formation. Finally, intensive geoarchaeological research in the Hasa (Coinman 1998) reveals that the natural formation processes, especially erosion, is more destructive in certain elevation bands in the long-term and can possibly be removing signs of human habitation from the landscape of the Hasa.

Overview

The start of the Holocene, ca. 10 Kyr B.P. brought increased humidity, which is observed in both sedimentary and the pollen data. These conditions favored arboreal taxa and forest regeneration. The Neolithic communities took advantage of the wet period for developing food-producing economies between ca. 9-7 Kyr B.P., with the exception of a brief drying trend at the end of the Pre-Pottery Neolithic. The wet phase continued into the Chalcolithic period; silt and loess were deposited, and arboreal plants continued to dominate the pollen spectra (MacDonald 2001: 598). There was an apparent increase in the number of sites and the area occupied at this time. Moreover, the first regionally distinct cultures (i.e. Ghasulian, Beersheba) emerged during the late Chalcolithic in the Southern Levant (Hanbury-Tenison 1986).

The Early Bronze I-III had the highest precipitation rates along with peaking anthropogenic activities, as the sediment data (i.e. aggradation and terrace formation) and pollen spectra (i.e. high values for anthropogenic plants and weeds but declining tree cover) indicate. Increasing social, political and economic complexity, which had already started during the Chalcolithic reached its climax during the earlier part of the Early Bronze. These changes brought the first urban formations in the region along the coasts of the Levant and facilitated larger inland settlements (Falconer and Savage 1995: 38).

The Early Bronze IV was the time of major desiccation in the Levant (except for the coastal plains) and Transjordan as indicated by sediments and pollen values. The archaeological evidence supported these climatic and environmental reconstructions. The declining number of sites, shifting settlement sizes from large to small and variable socioeconomic organization (i.e., occasionally increased regionalism) signaled return for decentralized life with rural emphasis. Some scholars believed that this desiccation was concurrent with the drought in the Near East and the central Europe (MacDonald 2001: 598).

Chapter 4

RESEARCH QUESTIONS AND METHODS

Introduction

Building on the conceptual models discussed in the previous chapter, this research assumes that strategies of socio-economic intensification and abatement (e.g., group fusion or aggregation and group fission or dispersal) in the southern Levant are reflected in both the changing sizes of sites and the varying diversity of site types through different periods of occupation in the Hasa.

Site size has been used widely in Near Eastern archaeology as an important indicator of function and type of subsistence (Schwartz and Falconer 1994: 1-3). Furthermore, combined with ethnographic data, archaeologists can compute the animal and human population based on the function, size and number of features such as houses, storage facilities, and pens. Such estimates can help to identify types of basic economic units in the society and their changes over time (Chesson 2003: 83). Moreover, as a proxy for population size and density, site size is important for estimating the extent of land undergoing human impacts in a region due to cultivation or grazing, as well as the scale and extent of human alteration on the landscape that is ecological footprint of human communities (sensu Collins et al. 2000).

Diversity of site function, on the other hand can indicate differences in the ways people make use of their surrounding environment and procured resources. Especially when coupled with site size data, higher site type diversity in a region may indicate economic maximization strategies. Such data can then be used to frame the socioeconomic changes the group is going through (e.g., the social and political organizational changes in relation with the economic gain or loss).

Against the backdrop of increasing socio-political and economic complexity, this research aims to evaluate spatial patterning in the context of Bentley's approach to social networks. Bentley's "Hub Network" is important for testing social complexity in my research area. In this concept certain agents (i.e., leaders, influential social figures as opposed to ordinary people such as peasants) may have extraordinary economic advantages, if they establish better (i.e., more numerous) connections within and outside the society. Once these well-connected agents start reaping the social and economic benefits of the networks, they develop exclusive advantages or rights for access or exploitation (Bentley 2003a: 17). This type of network encourages the wealth inequality in which few prosperous individuals combine their economic power in order to gain more at the expense of others in the society, leading to the analogy of "rich gets richer" (Bentley 2003a: 17). In this context, the Scale-free Network grows under the influence of such wealthier and more influential agents that are acting together (Bentley 2003b: 30). The 'rich gets richer' aspect of the Scale-free Networks brings prestige to select individuals, through wealth differentiation, which in turn affects the intra-group politics even if part of the wealth is shared, which fuels the economic imbalance (Bentley 2003b: 38-40). These qualities make the scale-free networks dynamic entities (Bentley 2003b: 40). The reflection of Scale-free Networks in regional settlement systems is in the form of few sites becoming highly connected (i.e., showing higher number of connections) within the network and continually increasing the number of connections as the network

grows (Bentley 2003b: 29). The remaining of sites in the area, on the other hand, show far fewer direct connections to other sites, instead the majority of sites interconnect via major nodes (Bentley 2003b: 29; Bentley and Maschner 2003: Figure 3.2). Therefore, Scale-free Networks exhibit power-law distribution, in regional archaeological record, in terms of numbers of connections to each site (Bentley 2003b: 29). Once graphed, such regional settlement systems should reveal a highly skewed distribution with a long tail, which is significantly different from the normal distribution (Bentley 2003b: 29) and can produce a linear regression in log-log plots (i.e., setting both axes logarithmic scale) (Bentley 2003b: 29, Figure 2.6; Bentley and Maschner 2003: Figure 3.5).

This study of the long-term changes in the settlement systems of the Hasa between the Chalcolithic and the Iron Age periods, and accompanying adaptations to natural and cultural changes in the landscape will combine archaeological and palaeoenvironmental (i.e., geomorphic and climatic) data from prior works, published and unpublished. I will apply a variety of statistical analyses and GIS applications to answer the research questions discussed below.

Data

In the course of surveys, MacDonald (1988) and Clark (Coinman 1998, 2000) discovered a total of 2200 sites in the Hasa drainage ranging in age from the Palaeolithic to the late Ottoman periods. In his doctoral dissertation research, Brett Hill prepared a computer database of these sites using MS Access (Hill 2002, 2006). However, this database contained coordinate information of sites based on old maps that were not accurate; usually causing a generally northeast offset of 200-300 meters in site locations.

This information was corrected, by the MEDLAND project team, using aerial photos, Google Earth images and digitizing the survey maps in order to provide greater accuracy for site locations, which is important for some raster-based GIS applications discussed in detail below. Because my research on the Hasa settlement systems has a limited temporal focus compared to Hill's research, my analyses use a subset of 335 sites from the total database. I further divided this subset of Hasa sites for analysis according to mean elevation above the sea level, drainages, site types, landforms and proximity to water sources such as streams or springs. These groups allow me to explore changes in the patterns of land use that might be related to one of these variables.

In my research I used JMP 8 software for statistical applications and GRASS for GIS analyses. Because neither JMP 8 nor GRASS GIS runs with MS Access, I converted my site database into Open Office Base, which is open source database management software.

Estimating Site Size and Function

The initial database built from field survey forms had a single maximum size value for each site regardless of the length of time that particular site was occupied. Also, it lacked information on the number of features at sites. More importantly, in some cases, the assigned site type did not agree well with the calculated site size -for example extremely large "hamlets" or very small "villages". The lack of such fine-grained data creates problems for a research design that focused on temporal changes in land use and site types. Site function assignments in archaeology are often based on subjective field assessments of visible features. For sites occupied or reoccupied over long time period, it

is important to estimate the site size for each period of occupation and combine this information with the number of features from that period in order to approximate the site function with greater accuracy. Hence, I compared the total number of features with the number of features from each period of occupation at a given site. Converting the number of features to percentages from a given period yielded the significance of that period at the site. Then, I used these percentages as a weighting factor for maximum site size to approximate the site size during each period of occupation. These calculations yielded estimates of site size and the number of features for every period recorded at a site.

The second source of data in this research is the selective site survey that I conducted in the Hasa in October 2007. The aim of this survey was to identify and record high-resolution data in the field about a group of sites, from the Chalcolithic to the Iron Age, that showed wide variation in terms of functions, landforms occupied, and associated drainage basins. Visiting these sites, mapping the natural and cultural features using GPS and then converting them to highly accurate site maps using ASTER and Google Earth imagery allowed me to document fine-scale spatial organization at the site level. These maps provide information about the range of activities and functions of sites, help estimated human and animal population, and permit inferences about the scale of impacts on the immediate environment (see the Drivers of Temporal Change in Social Organization and Settlement Systems section). This information can also be used to help calibrate the data from earlier surveys.

My research relies on three groups of data: the archaeological characteristics of sites (i.e., period, function, size, and number of features); data related to landscape or environmental factors (e.g., elevation, drainage, landform, degree and aspect of slope, distance to the nearest water source) and rates of deposition; and average annual temperature and precipitation. These data are used in order to answer the research questions described below.

Research Questions

The discussion and subsequent interpretation of the early metal age settlement patterns in the Hasa drainage focus especially on the drivers of temporal change in social organization and settlement systems, particularly settlement location, settlement density and site size as these are directly related to the phenomena included with in the concept of abandonment.

The Drivers of Temporal Change in Social Organization and Settlement Systems: As previously discussed, there is a relationship between levels of social organization and settlement patterns in terms of site size, function, and density. As social organization becomes more complex (e.g., emerging social differences on the basis of political influence, social charisma and/or differences in economic wealth), the settlements in a region tend to become diverse in terms of types of functions (i.e., from hamlets to ideological sites and cities that acted as centers of administration and exchange). Parallel to this, sites become denser in terms of their distribution across space (Stein 1994; Flannery 1998; Feinman 1998; Finkelstein 1999). Understanding the driving factor(s) in changing organization and settlement systems is important for accurately reconstructing

the past relationships among critical variables such as population and resource use, which can be used to infer human activities in their natural and cultural contexts.

Question: To what degree, do changes in the settlement patterns and social organization represent the responses of society to changing environmental conditions, increased conflict, and/or emergence of exchange mechanisms?

Discussion: If changes in settlement and social organization are responses to economic, social and environmental variables, it is expected that social organization and settlement patterns will co-vary with changes in these factors. In this case, the social organization and the settlement patterns are expected to follow oscillations in environmental conditions (i.e., increased complexity in organization and settlement during climatically more favorable periods), changes in the importance of conflict in the social environment (i.e., reduced social complexity and settlement activity), or changes (i.e., towards increased complexity) in economic conditions (e.g., the emergence of new tools to accumulate material wealth, such as inter-regional trade).

Testing: The population density across the Hasa during the early metal ages is a reliable indicator of changing settlement dynamics and shifting human-environment interactions, when combined with site type diversity and size information. The population calculations are complex and there are alternative methods of making such estimates.

In their population calculations throughout the Bronze and Iron ages, Broshi and Gophna relied on the archaeological data from the west of the Jordan Rift Valley (i.e., modern day Israel) between Galilee in the north and Judea in the south. They calculated the total area as 26,000 square kilometers and used settlement data from surveys that covered 14,000 square kilometers (Broshi and Gophna 1984: 41). In their calculations, sites (e.g., Arad) and regions (i.e., Negev) with heavy nomadic aspects were excluded. Broshi and Gophna compared the settlement density and population coefficients used for Mesopotamian settlements and for some of the oldest cities in the region such as Damascus and Jerusalem (1984: 41). Based on these comparisons, the results can be summarized as follows:

| Region | Population Coefficient per Hectare |
|-----------------------|------------------------------------|
| Mesopotamia | 300-500 people / Hectare |
| Damascus or Jerusalem | 400-500 people / Hectare |
| Galilee to Judea* | 250 people / Hectare |

Table 1. The comparative population coefficients used by Gophna and Broshi (1986) and Broshi (1993). (*)The coefficient for the region between Galilee and Judea indicates 0.025 people per square meter.

The comparably lower coefficient for the Levant are directly related the demographic (i.e., initially low population density of the region in the periods preceding the Early Bronze Age) and environmental (e.g., the wider diversity and more frequent dispersal of resources in Mesopotamia and northern Levant) factors. Broshi and Gophna calculated the total built up area for the Bronze and Iron ages (Gophna and Broshi 1986, Broshi 1993) and used these for estimating population.

| Period | Total Settlement Area (Ha.) | Total Estimated Population (250 people/Ha.) |
|----------------------|--------------------------------|---|
| Early Bronze Age II | 600 Ha. | 150,000 people |
| Middle Bronze Age II | 400-550 На. | 100,000-140,000 people |
| Late Bronze Age | 200-250 На. | 50,000-60,000 people |
| Iron Age II | 1,600 Ha. | 400,000 people |

 Table 2. The population estimates for the Galilee-Judea region by Gophna and Broshi (1986).

The results suggest sudden and significant Iron Age population increase (around 4% annually), which may indicate errors in calculations. However, the general pattern of these results is important; the population, hence the density of settlement activity, showed an oscillating pattern in the west of the Jordan Rift Valley through these calculations. Given the fact that the west side of the Valley had milder climatic conditions (i.e., the Mediterranean type mostly) and the topography was more stable, it had higher capacity of accommodating people than the regions east of the Valley, such as the Hasa.

To evaluate the Hasa data with respect to this question, I compiled data on the population (i.e., the estimated number of people living in the drainage per period), demography (i.e., the rough composition of the population on the basis of subsistence patterns), economic orientation (i.e., agriculture, pastoralism) and resource use in addition to environmental data and other information about social unity (i.e., conflicts) and integration (e.g., long-distance trade relations). The analyses of these data focused on the type of social organization in the Hasa in each period (i.e., whether the tribal groups aggregated and established a more complex social organization under chiefs or, dispersed

across the Hasa and made decisions at the level of families and extended kin for survival). These were then compared with settlement patterns in the archaeological record of that period.

The estimates for population and demography were based on my selective site survey and digital mapping of these sites (Figure 1 and Table 3), which is explained in detail earlier in this chapter. Using the fine-scale spatial organization at these sites as representative of the Hasa sites, I made population estimates, for the Bronze and Iron ages, using the common parameters (i.e., calculating the built up area for each period and multiplying that with a lower population coefficient than the Galilee-Judea region) for the southern Levant (Broshi and Gophna 1984; Broshi and Gophna 1986; Broshi 1993). The environment of the Hasa shows greater fluctuations and therefore, the population coefficients used for the Hasa is not a single figure but rather it is a range. Using the types of features (i.e., pens, houses, terrace walls, workshops), I identified site functions and outlined the demographic aspects (e.g., agriculturalist, pastoralist, or a combination) of the Hasa population. Such information provided insights on the economic orientation and the intensity of resource use, which were then used to reconstruct the scale and intensity of human impacts (e.g., local vs. regional, intensive vs. extensive).


Figure 4. The site of WHS-23 El-Mashmil in the west Hasa with archaeological and natural features mapped on ASTER imagery and pointed by arrows.

| | | | | Terrace | | |
|-------------|-------|------|---------|---------|----------|-----------|
| Site Number | Rooms | Pens | Storage | Walls | Function | Period |
| WHS 10 | 3 | 2 | 0 | 12 | LgEcon | IA |
| | 19 | 2 | 2 | 15 | Sm&Lg | EBIV-LB |
| WHS 23 | 10 | ۷. | 5 | 15 | Econ | and IA |
| | 1 | 1 | 1 | 0 | | EBIV-LB |
| WHS 28 | 4 | 1 | 1 | 0 | A-F | and IA |
| | 1 | 1 | 2 | 0 | | EB, EBIV- |
| WHS 61 | 4 | 1 | 5 | 0 | SmEcon | LB, IA |
| | 2 | 1 | 0 | 0 | | EB and |
| WHS 64 | 2 | 1 | 0 | 0 | SmEcon | EBIV-LB |
| | 2 | 0 | 0 | 0 | | EBIV-LB |
| WHS 147 | Z | 0 | 0 | 0 | SmEcon | and IA |

Table 3. Has sites that are digitally mapped and used as basis for verifying site functions. These thirty sites reflect functional and environmental diversity of the early metal age settlements in the region.

| | | | | Terrace | | |
|-------------|-------|------|---------|---------|----------|--------------|
| Site Number | Rooms | Pens | Storage | Walls | Function | Period |
| WHS 165 | 2 | 0 | 0 | 0 | SmEcon | EB |
| | 1 | 1 | 0 | 6 | Sm&Lg | EBIV-LB |
| WHS 172 | 4 | 1 | 0 | 0 | Econ | and IA |
| WHS 212 | 4 | 1 | 1 | 0 | LgEcon | IA |
| WHS 260 | 3 | 1 | 1 | 0 | SmEcon | EB |
| WHS 367 | 2 | 0 | 0 | 0 | LgEcon | EB and IA |
| WHS 615 | 8 | 2 | 2 | 0 | LgEcon | IA |
| WHS 783 | 6 | 1 | 3 | 0 | Mltry | EB |
| WHS 855 | 6 | 1 | 4 | 0 | SmEcon | EB |
| WHS 856 | 1 | 1 | 0 | 0 | A-F | Chal |
| WHS 866 | 1 | 3 | 2 | 0 | SmEcon | Chal |
| WHNBS 186 | 2 | 0 | 3 | 0 | SmEcon | EB and IA |
| WHNBS 216 | 2 | 1 | 2 | 0 | SmEcon | IA |
| WHNBS 231 | 3 | 1 | 1 | 0 | SmEcon | Chal |
| WHNBS 311 | 1 | 5 | 6 | 0 | SmEcon | Chal and IA |
| WHNBS 338 | 1 | 2 | 2 | 0 | SmEcon | IA |
| WHNBS 349 | 16 | 4 | 3 | 0 | LgEcon | EB |
| WHNBS 350 | 3 | 2 | 10 | 5 | SmEcon | IA |
| WHNBS 356 | 1 | 1 | 1 | 0 | SmEcon | IA |
| WHNBS 395 | 1 | 1 | 1 | 0 | SmEcon | IA |
| WHNBS 396 | 1 | 0 | 0 | 0 | Cave | EB and IA |
| WHNBS 398 | 1 | 1 | 0 | 0 | SmEcon | IA |
| | 10 | 5 | 15 | 0 | | Chal, EB and |
| WHNBS 434 | 10 | 3 | 13 | 0 | SmEcon | IA |
| | 1 | 0 | 1 | 0 | | EB and |
| WHNBS 467 | 1 | 0 | 1 | 0 | SmEcon | EBIV-LB |
| | 1 | 1 | 0 | 0 | | Chal, EB and |
| WHNBS 493 | 1 | 1 | 0 | 0 | SmEcon | IA |

Table 3. (continued). Has sites that are digitally mapped and used as basis for verifying site functions. These thirty sites reflect functional and environmental diversity of the early metal age settlements in the region.

| Period | Total Settlement Area (Ha.) | Population Coefficient (min/max) | Total Min. Estimated Population (per Ha.) | Total Max. Estimated Population (per Ha.) |
|--------------|-----------------------------------|--|--|--|
| Chalcolithic | 4.6 | 100/150 | 460 | 690 |
| EB I-III | 11.47 | 100/150 | 1,147 | 1,720.5 |
| EB IV-LB | 4.8 | 100/150 | 480 | 720 |
| IA | 43.52 | 100/150 | 4,352 | 6,528 |

Table 4. The population estimates for the Hasa. 250 people per Hectare coefficient for the Galilee-Judea region, which is on the west side of the Jordan River, is significantly reduced.

| Period | Demographic Characteristic |
|--------------|--|
| Chalcolithic | Largely pastoralist with low population and settlement density and feature types such as pens |
| EB I-III | Mostly agriculturalist with high settlement and population density and site types such as villages and increased number of storage features |
| EB IV-LB | Mainly pastoralist with low population and settlement density and feature types such as pens |
| IA | Essentially pastoralist following the peripheralization to meet the demands of the core (i.e., the Moabite state) however, long-distance trade was economically significant as well. |

Table 5. The summary table for the demographic characteristics of the Hasa population based on population density, settlement patterns and site complexity.

The population estimates, demographic characteristics of the Hasa, the patterns of resource use were combined with environmental data, data on conflict and data on exchange in order to analyze temporal changes in settlement systems within the Scalefree Network framework of Bentley, mentioned above and discussed in the theory chapter. <u>Settlement Location</u>: Settlement location can document how the settlement systems spatio-temporally change in relation with physical properties of a locale (i.e., elevation, drainages, landforms or proximity to different water sources), security concerns, and trade relations besides other factors such as changes in social organization, the levels of economic and technological complexity. These patterns can also inform us less directly about the land use (i.e., intensive vs. extensive) and environmental risk management practices (e.g., economic maximization vs. self-sufficiency) in the Hasa, which then may be used for identifying phases of aggregation and dispersal, as well as their impacts on the fragile environmental dynamics of the Hasa.

Ecological Determinants of Settlement

Question: Are there temporal differences in site locations that result from changes in human ecology due to adjustments in social and economic organization and/or changes in environmental conditions?

Discussion: The archaeological record can indicate differences in site locations in terms of elevation, drainage, terrain, and site types preferred in each period. Significant ecological criteria that could be responsible for settlement activities include rainfall, availability of water, soil quality, tilling, growing season, types of produce, risk of erosion. Temporal variation in site locations also may provide critical information regarding the type and the intensity of subsistence practices for each period, as well as the possibility of anthropogenic impacts on the landscape. Ecological relationships between site locale and the biophysical environment can indicate how people adapted their settlement systems (i.e., hence, the subsistence practices) to major climatic and

environmental changes at the end of the Early Bronze Age, when major socio-political and environmental crises are indicated by the archaeological and palaeoenvironmental record (Dalfes, Kukla and Weiss 1997).

The theoretical framework in the preceding chapter suggests that during periods of low population density (i.e., Chalcolithic and Chalcolithic-Early Bronze transition) or under environmental and socio-political stress (e.g., Early Bronze IV through the end of the Late Bronze), settlement systems remain small or contract. At such times, small tribal groups tend to settle at places where precipitation is better, access to critical resources such as tillable soil and water are at low cost, the terrain is well-protected. During periods of climatic amelioration, such as the Early Bronze I-III, and under certain political, socioeconomic conditions that allow regional integration of the Hasa with the neighboring regions, such as the Iron Age territorial state formations, the settlement systems expand to make maximal use of the landscape through various methods. During periods of more favorable climate, population and land use may also expand into a wider range of geographic settings (e.g., elevation and/or terrain) for intensive or extensive agricultural and pastoral (specifically, goat herding) production regardless of risks or impacts on the landscape.

One obvious potential change in settlement locations is related to the elevation because relationships between elevation, precipitation and tillable land. The transitional character of the Hasa environment from semi-arid to desert, the apparent drop in precipitation after EB III, the sporadic distribution of limited resources in the region, a cycle of social and political cooperation/competition among the tribes (see below), and shifting focus of subsistence between agropastoralism and pastoralism-oriented agriculture from one period to another can be expressed in elevational differences of settlements. For example, I expect that landforms that are riskier for erosion (i.e., ridges, steeply sloping terrains) are settled and used more during periods of dense settlement activities whereas in times of social crises, well-protected terrains are preferred (i.e., peaks).

During the Chalcolithic period with low population density, I expect that most settlements should be located within a restricted elevational range (i.e., mid/high altitude zone) because of easier access to water under wet climatic conditions and presumed pastoralist orientation of subsistence. Social cohesion can also be developed rapidly under hospitable climatic conditions and low population density, where people do not have to compete for resources such as pasture or water. In terms of terrain preferences, these sites also are expected to occupy select terrains (i.e., low diversity) with greater geological stability, such as level terrain instead of peaks or ridges.

The EB I-III period represents the first phase of denser population and increased settlement activity across the Hasa. Precipitation increases in this period (see the section on climatic change in the next chapter), and the combined increase in the number of small economic sites and the emergence of villages suggest a shift in subsistence from pastoralism to mainly agriculture. This is also the period when terrace agriculture first becomes widespread. Due to denser population and settlement, sites are expected to spread across the Hasa drainage, using variety of resources for different needs of the population (i.e., extensive exploitation of resources) creating an increase in site type diversity. However, resource diversity and availability are limited outside a limited range of elevations, majority of subsistence activities (and, hence, subsistence-oriented sites) should still be concentrated within a narrow and well-defined range. In relation with the changes in subsistence type and level of intensity, I expect that the inhabitants occupied a more diverse set of landforms at least occasionally, and as well as terrains of higher risk for erosion (i.e., ridges, peaks) as a result of expansion across the landscape are settled.

The EB IV-LB period represents a significant decline in population in the Hasa and a major change in social organization. Settlement data suggest population and site densities similar to the Chalcolithic. This long-term change in the Hasa is unique in terms of the archaeological record of the region, which generally indicates population increase and growing social complexity. The major subsistence type may again be pastoralism, based on the features at sites. Under prolonged aridification, already limited and patchy resources may have become more difficult to procure. These conditions would have promoted increased inter-tribal competition for diminishing resources for survival, in spite of low population densities, increasing the potential for social tension and conflict. Settlements of this period are anticipated to be distributed widely across the elevation ranges in the Hasa in order to make use of wider range of resources over the whole drainage and reduce social conflicts. Sites also should exhibit minimal diversity in size and functional type. The terrain preferences for this period are expected to be limited to ones that provide higher precipitation while providing protection (i.e., peaks, ridges). The IA is the phase of densest settlement in the early metal ages. The site frequency is double that of the EB I-III period. Climatically, this is the most arid period however, since precipitation continues to drop. The scale of increase in settlement activity under climatically prohibitive conditions suggests an increased importance of possible external factors (i.e., peripheralization of the Hasa, see the second research question). Considering the increase in site diversity, population and settlement density, it is clear that the IA settlement system in the Hasa signals the return of extensive exploitation of diverse resources, similar to EB I-III period, but at a much larger scale possibly as a social, political and economic connections with the Moabite state on the Karak Plateau.

The possible external socio-political influence of the Moabite state and the integration of the Hasa into the inter-regional caravan trade may suggest the replacement of tribal competition with cooperation to produce enough surplus, which then can be traded. Given the arid climatic conditions and the assumption that the subsistence of this period largely relies on agriculture, it is predicted the IA settlements will be found within a narrow range of higher elevation zones since these are the only ones that can provide sufficient precipitation for agricultural activities. If such concentrations in elevation ranges exist in the EB I-III and then in IA, the anthropogenic impacts (i.e., erosion and desertification) should be obvious on landforms occupied. Terrain preferences are anticipated to parallel the EB I-III period; highly diverse set of terrains settled and used for various activities, including the high-risk landforms for anthropogenic impacts mentioned above.

Testing: The testing of the ecological determinants of settlement involves GIS applications and statistical tools, which are discussed in detail under the Analytical Methods section in this chapter. The first group of testing focuses on tracking the environmental change (i.e., natural, climate-driven). Using spatio-temporal variations in crucial factors such as precipitation and temperature in the Hasa between 3,500-700 BC, the palaeoenvironmental context for interpreting the periodic changes in the settlement systems is established. These variables are plotted against terrain, site function and site complexity (i.e., the calculated number of features) in order to identify possible relationships among them. Additionally, the relationship between such climatic variables and their impacts on the fluvial regime in the Hasa is studied through the location and size of watersheds, which are important resources in an environmentally marginal place like the Hasa. Combining the precipitation and temperature data with the watershed data, temporal changes in site locations can be better illustrated from the perspective of lack or presence of critical resources (i.e., not only the water but also the rates of sediment erosion or deposition at a given site) in the Hasa. Finally, estimated cumulative changes in the Hasa landscape during the early metal ages can be displayed on maps, which are generated in a GIS platform, by taking the geological and climatic dimensions into account.

The second group of testing focuses on the general characteristics of site distribution according to elevation in order to test the expectations discussed above and possible anthropogenic impacts of long-term, continuous habitation on the Hasa landscape using GIS and statistical tools. Temperature and precipitation are the fundamental climatic variables examined over varying elevation ranges. The spatiotemporal variations in these variables are illustrated in a GIS platform to test whether change in these variables may contribute to shifts in subsistence activities. Site distribution across the Hasa landscape also is analyzed to identify terrain preferences (i.e., landforms, elevation), as well as the slope and aspect (i.e., the facing direction of slopes) details of sites. The results of these analyses are presented as absolute and relative area of coverage. These are used for scaling of site distribution in terms of frequency and size (see below). The results of such analyses provide information for discussing the extent and magnitude of anthropogenic impacts.

The watershed analyses in GIS platform mentioned in the previous section can also be used to test the relationships between elevation range and availability of water, proximity to year-round, reliable sources of water as well as the landscape stability. This hydrologic modeling also can provide information about rates of soil accumulation or loss in this zone. These environmental characteristics are then compared with site function, size, and internal complexity. The last GIS-based testing is aimed at estimating both the natural landscape evolution (i.e., using rainfall, land cover, soil density parameters and leaving the anthropogenic factors out) and the possible extent of anthropogenic landscape modifications (i.e., through extensive agropastoral land use) throughout the periods. Especially for the anthropogenic impacts on the landscape, the land use in the zones of dense settlement activity is modeled for longer time periods (e.g., 200 years) in order to assess how the resource availability changes and people react to such modifications in the environment. Statistical testing of the temporal changes in elevation range uses ANOVA to untangle relationships among altitude, site function and internal complexity, temporally and spatially (i.e., from one terrain type to another). In order to test the possibility of preferential occupation of certain terrain types, slopes or aspect categories for specific activities, scaling (i.e., the ratio of the number of sites to the total area covered by each landform) is applied to site frequency and size data. The site density (the number of sites per square kilometer) for each period is also used to assess periodic oscillations in site locations. ANOVA and box plots are used to identify non-random changes in settlement systems due to distances from streams or sediment accumulation rates. These assessments reveal possible relationships among proximity to water sources, site function and internal complexity levels in each period.

The overall patterns for temporal changes in settlement location are also discussed in relation to signatures of hierarchy and heterarchy. Following the discussion in the theory chapter, I expect to observe that the Chalcolithic settlement patterns will lack any sign of group fusion, which typically creates settlement hierarchy. The settlement hierarchy is identified from the presence of few large size sites (i.e., cities, towns, or villages) while smaller site types (e.g., farms, hamlets) dominate the settlement types. Such hierarchies of settlement systems are reliable indicators of hierarchic social organizations where central nodes of control are actively involved in decision-making processes. I anticipate a significant reversal in this trend during the Early Bronze I-III, with signs of groups coming together and creating large sites (i.e., villages) that signaled economic maximizations instead of self-sufficiency. I expect a return to heterarchy during the EBIV-LB when the effects of increasing aridity in the Levant acutely affected the Hasa. This would be evident in the archaeological record in the form of depopulation, abandonment, and group fission. Consequently, smaller groups on the landscape cannot create settlement hierarchies and reduced site size and diversity support heterarchic social organization. This phase does not indicate a return to the Chalcolithic in terms of land use practices, however, I assume that safety was equally important as the available resources in deciding the location of a site because of increased competition for more limited resources in the Hasa under drier climatic conditions and possibly environmental deterioration due to human impacts of the preceding period. The settlement patterns of the Iron Age is expected to be parallel to the Early Bronze I-III; population increased in the Hasa partly because the climatic conditions were better but more importantly the Hasa gained a peripheral role between the territorial states in the region. Due to this role, economic maximization is evident and it is anticipated that the Iron Age settlement patterns will support these assumptions by indicating settlement activity on wide variety of landforms and types. Following these changes along with the emergence of trade routes, the Hasa population is expected to show group fusion, forming large settlements and establishing hierarchies.

The scale-free hierarchy concept (see the Theory chapter) forms the basis of testing the Hasa settlement data for signs of hierarchic social organization. According to this recent approach to the formation and development of complex social networks, there are fewer large and well-connected sites in a social system. The majority of sites, on the other hand, are small in size, hence they have limited (i.e., low) number of connections.

Smaller sites attach themselves with one of the larger sites and therefore, the site with many more connections tend to grow faster in time ("Preferential Attachment" concept, Figure 3) in relation to the size of their connections with other sites. Application of scale-free network testing requires log-log plotting of the number of sites with site size data, seeking for a regression line that decreases (i.e., the number of sites become fewer) as the site size grows.

Cooperation and Conflict

Question: To what degree did shifts between conflict and cooperation influence selection of site locations? What are the settlement consequences of local cooperation/conflict versus these social phenomena at regional scales and beyond?

Discussion: Before discussing the implications of cooperation and conflict for locating sites on a landscape, it may be helpful to define these terms for the purpose of my research.

Cooperation vs. competition: The cycles of aggregation and dispersal of the Hasa population are likely results from various, interrelated and complex factors that include not only environmental conditions, but also the tribal politics (e.g., cooperation or competition for resources, access to land) and group dynamics (i.e., fusion and fission) (e.g. see Hill 2006).

Competition: In a landscape like the Hasa, where resources (e.g., arable soil, water, grassland, timber) already are scarce and their distribution is sporadic, the social dynamics change and the security concerns can become more significant when the tribes have to compete for resources under deteriorating climatic and environmental conditions

(e.g., EBIV-LB). In such circumstances, security concerns due to diminishing resource diversity and availability in the Hasa can lead to the fissioning of groups along kinship or lineages, putting families at the center of decision-making process, and ultimately reducing social cohesion. Following the Dimorphic Society and Heterarchy concepts, a resilient social base is expected to opt for group fission and to spread out across the landscape in order to establish survival mechanisms, such as restricting access to ancestral or tribal lands and resources for self-sufficiency (Chesson 2003: 86-87). In a region as marginal as the Hasa for its climate and resource distribution, group fissioning and competition for resources may bring frequent conflicts among the lineages and tribes. However, due to low population density and the nature of settlement systems (i.e., hamlets, farms across the drainage) in EBIV-LB period, military sites may not have been present under these conditions.

Cooperation: Although historical data suggest that there are conflicts among the tribal groups (i.e., Bedouins), the Chalcolithic period is different from the historical periods, especially in terms of its significantly low population density and resources in the Hasa would have been sufficient for its few inhabitants. Therefore, the significance of security concerns may have been much less under phases of climatic and environmental stability as well as low population density. The population increase and group fusion with the aim of self-generated economic maximization in Early Bronze I-III may have led to intertribal cooperation for resource procurement hence permitting a generally peaceful coexistence among the tribes. The emergence of the first socially complex entities (i.e., villages) may have been results of such social negotiations. Even if it is possible to argue

that population increase and settlement expansion might have led to conflicts over resources, both scarcity and patchy distribution of vital resources in the Hasa possibly made the hegemony over them by a few groups difficult.

The socio-economic setting of the Iron Age (i.e., the Moabite and Edomite state formations around the Hasa and possible use of the drainage by the Moab as a periphery) would have kept the security concerns at the minimum since lineages were under the control of chiefs. However the Iron Age state formations around the Hasa drainage may have had more direct influence on settlement and land use patterns, which also influenced on perceptions of security for the Hasa population (Hill 2006). Under these conditions, the security concerns might have focused more on protecting the borders and, more importantly, to protect the Arabian caravan route in the western Hasa (Bienkowski and van der Steen 2001: 32-34, 36, 40-41).

As a consequence of fission/fusion social mechanism, it is expected that military sites protected the economic investments across the Hasa during phases of cooperation rather than during times of local intergroup competition and conflict. The testing of the issues raised in this section is discussed below.

Testing: The first step in the assessment of the military sites is the changes in the temporal distribution and the composition of forts and towers. Towers are expected to dominate the distribution since they can be maintained by fewer number of people and it is easier to establish a defensive network by using towers, which do not require feeding and taking care of a large group. However, the overall temporal changes, both in the ratio of towers to forts and the spatial distribution of military sites in the Hasa, are anticipated

to demonstrate the changing perception of groups to issues related to security and creating a defensive mechanism (i.e., the existence of a network of military sites in the IA vs. lack of such defensive system in Chalcolithic or EB IV-LB). The presence of forts provides important clues about the organizational capacity of society in terms of creating and maintaining an organized defensive structure. The existence of a network of forts (e.g., in the IA), which might have several functions as discussed below, can be attributed to large-scale social negotiations and cooperative dynamics among the tribes. Towers, on the other hand, suggest smaller, less complex but more efficient system of defense (e.g., in the EB I-III). Such system might have been the result of relatively low-population density, in comparison with the IA, and locally developing socio-political dynamics (i.e., as opposed to the periphery role of the Hasa in the IA).

The temporal changes in sizes of military sites provide additional information about the society's ability to defend itself, and are an indicator of how seriously people assessed risks and threats. If security concerns became more diverse from the EB I-III to the IA (i.e., from protecting local economic investments to defending the trade routes and border protection), then it may be indicated by increasing diversity in size and morphology of military sites. An increasing variety of forms of military sites may suggest more complex social organization in the Hasa. The emergence of such defensive systems may be independent of environmental factors, especially because the IA witnessed continuing aridification, as previously noted. These complex socio-political systems then might have come out largely as results of tribal cooperation and external political ties of the Hasa. Comparing the site densities between military and non-military types in each period and the military site density on each terrain type can provide insights on security issues in each period. If military sites are increasingly related to expanding trade routes and border defense of complex polities, there may be more military sites per square kilometer and more military sites relative to other sites during the IA in comparison with the EB I-III.

I assess temporal changes in functions of military sites using GIS and statistical tools. The distribution of military sites is tested in relation to terrain types, proximity to certain site types (e.g., if military sites tend to remain close to villages or other settlements of economic significance), and drainages (e.g., if the military sites formed clusters in certain areas of the Hasa).

The testing of the EBIV-LB period for the security concerns and cooperation/competition mechanisms is challenging for several reasons. Firstly, the apparent depopulation and large-scale abandonment seems largely due to environmental factors. Secondly, there is only a single military site, which is insufficient for analysis by itself. Therefore, all of the sites from this period are assessed from the perspective of competition and its probable impacts on choosing site locations. EB IV-LB sites are evaluated for the protective capacity of the terrains where they were established, such as hilltops and ridges. The results are then compared with the other periods in terms of their preferences for well-protected terrain types and how densely these were settled.

Finally, I examine evidence for the "peripheralization" of the Hasa during the Iron Age. In order to understand the general characteristics of the settlement systems of this period, it is important to critically evaluate whether the Hasa became a periphery of the Moabite state in the north. If so, the Moabites may have been interested in extensive use of resources (e.g., the pastoralist society in the Hasa) across the drainage as well as creating a buffer with Edom in the south while controlling trade routes from the Arabian Peninsula. Under these conditions, there should be denser settlement activity with highly diverse site types and numerous administrative centers (i.e. villages) spread across the Hasa. In terms of the distribution of military sites, if the Moabites treated Hasa as buffer and attempted to protect the boundaries of the Hasa with Edom, it may be revealed by military site patterns. Again, GIS is used to quantitatively assess settlement patterns from this and the EB to LB periods.

Trade and Exchange

Question: In what ways have the establishment of major trade routes affected site location and abandonment?

Discussion: The role of cooperation among the lineages for economic maximization during the Early Bronze I-III and Iron Age, the significance of the state-level social organizations around the Hasa, and the integration of the region into the Arabian caravan trade in the Iron Age have already been mentioned for their potential impacts on the Hasa settlement systems. For the recent identification of post-Roman period roads in the Hasa, Konstantinos and others (2007) provide a detailed report.

Existing Roads and Routes: An additional aspect to consider in discussing the evolution of the settlement systems is the proximity of sites to other trade routes passing through the Hasa. The environmental conditions of the Hasa (i.e., highly dissected topography

and significant environmental variations from one end of the Hasa drainage to the other) may have limited the number of trade routes in the area. The only ancient road that still survives, in parts in the Hasa is the Roman Via Nova that crosses the drainage from north to south at the mid-point, near Wadi Anmein (the segment of the King's Highway in the Hasa, see the discussion below). This mainly had a military function in the Roman period. However, the route for the Arabian caravan trade, which was active in the IA, is highly debated. Although a consensus has not yet been reached, the scholarly opinions favor two possible routes that originate in western Arabian Peninsula. The southern route reaches Edom, via the Wadi Arabah and then crosses the Negev, ending at Beersheba (Finkelstein 1992, 1995). The northern route continues into the Hasa, crosses Transjordan following the King's Highway (i.e., Via Nova in the Hasa) and ends at Damascus (Herr 1997, Bienkowski 2001).

Earlier Roads and Routes: Although it is difficult to accurately locate earlier roads and routes, due to preservation issues and geomorphic changes, there seems to be few probable locations in the Hasa for such routes and these are expected to be mainly in the western terminus of the drainage, which provides easier crossing alternatives of the Jordan Rift Valley and because the eastern Hasa is desert-like.

The identification of pre-Iron Age roads and routes largely depends on GIS-based analyses of settlements along the major valleys. The valleys with long N-S passage (e.g., Afra, Anmein) might have been favored over others (see the Testing section below). One marker of now lost trade routes could be a proportional increase in settlement density near major valleys. This would be especially notable during the periods of settlement expansion and economic intensification (i.e., Early Bronze I-III and Iron Age), when the population was able to produce more surplus for exchange or when it becomes part of long-distance trade networks such as the Arabian caravan trade. Consequently, sites along or near such routes may have been larger in size and had higher levels of internal complexity (i.e., high number of features) than the sites of the same period that were not located along these probable routes.

The emergence of such settlement patterns also may have had socio-political implications. If such routes were present in the EB I-III, it would imply that the group fusion and strategies of economic maximization suggested for this period, established by the Hasa population itself, results in sufficient accumulation of goods for the establishment of exchange systems (see the "Cooperation and Conflict" section above). Furthermore, these may imply higher levels of economic and social integration of the Hasa population under economic maximization. This might have contributed to the emerging social complexity in the EB I-III period by creating disproportionate accumulation of wealth, which then led to social and political differentiation as discussed by Johnson (1982) and Bentley (2003a, 2003b). The maintenance, organization and administration might have been he responsibility of a select group in the society, who made decisions about every aspect of production. Given the tribal nature of social organization, under economic maximization, only chiefs had sufficient social prestige to undertake such functions.

Relationships between probable IA routes and the Hasa settlement systems may also provide information about the peripheral role of the Hasa to the Moabite state in the north. The trade routes could also act as corridors of social integration of the periphery to the Karak Plateau. Such integration should not be viewed as a one-way traffic of goods (i.e., the resource extraction from the Hasa), but rather a two-way road that also brought political and social influence from the north. In this sense, these routes may be viewed as sources of direct political and economic influence over the Hasa. An additional function of these routes can be military especially because the Hasa is a border between the Moabite and the Edomite states –for the resources of the Moab and Edom states, see Andrews and others (2002), and Levy and others (2003)–

Testing: Testing the relationship between trade routes and settlement dynamics requires the use of GIS for analyses. The first step in testing the predictions relies on the identification of the least-cost routes from the south to the north (i.e., the Karak Plateau or As-Safi) in the western Hasa. These can be calculated in a GIS platform, which is capable of mapping such route between two points.

The identified routes then need to be compared with the known ones (i.e., Via Nova) as well as the overall settlement distribution for further analyses. ANOVA and GIS are used to assess the settlement type diversity (i.e., the presence of administrative sites in addition to sites that serve different needs) during the Early Bronze and Iron ages. Settlement diversity is measured by the number of types represented along each route within a buffer (i.e., a zone of 1 kilometer around the route) of relatively easier walking distance depending on the slope of the terrain. A density index of settlements is also created within the same buffer along the routes, providing a measure of the relationship between trade and its probable effects on settlement patterns. The internal complexity

(i.e., economic wealth from trade) of sites along the suggested and known routes and within the buffer area is also an important indicator for the impacts of trade on settlement systems. Higher site density and type diversity along the routes of trade in the EB I-III and IA may be associated with higher internal complexity as a result of economic wealth from trade.

The testing of the settlement systems proposed above focuses on the settlements in the southern plateau since the great majority of the IA villages and military sites are located here. I will compare the sites (i.e., villages, military sites and other types) that are within the buffer zone of the trade routes with sites that are in other parts of the Hasa, for complexity in addition to evaluating settlement diversity in the southern plateau in order to identify whether trade is the sole factor that attract sites to this part of the Hasa. *Analytical Methods*

<u>Spatial Methods</u>: I use GIS in my research, which is an integrated technology for collection, analysis, and interpretation of spatial as well as space-time related aspects of human-environment interactions (Conolly and Lake 2006:11). Data analysis in GIS platform can involve raster or vector operations. While vector is a type of data stored and manipulated as geometric objects (i.e., a wall, the outline of a feature or a point which denotes a site) raster refers to data stored as a rectangular matrix of cells containing values (i.e., coordinates, elevation, slope) across a continuous surface such as the Hasa drainage (Wheatley and Gillings 2002: 32-34; Conolly and Lake 2006: 24-28; Neteler and Mitasova 2007: 7-10). Vector data generally result from digitizing features and attributes (i.e., topology, coordinate, length) and have associated attributes stored in

databases (Wheatley and Gillings 2002: 34; Conolly and Lake 2006: 25-27). Raster data on the other hand are commonly derived from samples of remotely sensed imagery. Each raster cell stores specific information about a particular location on the face of the earth (Wheatley and Gillings 2002: 33; Neteler and Mitasova 2007: 8-9, 54). Depending on the resolution of raster imagery, the number of cells may be in millions for a region (e.g., 10 meter resolution map of the Hasa has 9,950,073 cells).

The analyses in my research use GRASS GIS, which is open source GIS software especially useful for topographic analysis and modeling (Neteler and Mitasova 2008: xi) with powerful tools for spatial analysis of raster data. Since the majority of my research questions are about the landscape, I used raster operations for most analyses. Many of these operations required digital elevation models (DEMs) of the Hasa drainage. A DEM is a raster map that represents terrain by recording the elevation for each cell. Using a DEM, GRASS can identify diverse landscape elements (i.e., hilltops, saddles, wadis, flatlands) (Figures 30 and 44), as well as the location and size (e.g., in either square meters or cell sizes) of watersheds (Figure 48) the might have been, how many cells drained into sites (hence, the rate of sediment accumulation), how extensive the stream network was.

In addition to using the raster analysis modules that came with the GRASS package, I also employ several custom scripts, the Landscape Dynamics package developed by the MEDLAND research team, to calculate and illustrate the rates of landscape change over long periods of time under varying intensities of land use by humans and changing environmental conditions (Barton, Ullah and Mitasova 2010). The

first of these modules, 'r.soil.depth', creates a raster map of soil depth, based on slope curvature information, using a DEM. This map is then used by a more complex script called r.landscape.evol, which calculates for a specified number of years, net rates of erosion/deposition in the research area, using empirical variables such as rainfall, land cover, soil erodibility and slope. Additional scripts in the Land Dynamics package are 'r.agropast.extensive' and 'r.agropast.intensive', which calculate the impacts of both extensive and intensive agropastoralism on the landscape, using variables such as the size of agricultural catchments, the percentages of these catchments to be used as fields and grazed land, as well as their sizes. These modules are used to prepare maps that show how the land cover was affected after specified number of years under set intensity level of activities and consequently, how the landscape responded to erosional forces due to changes in land cover by calculating c-factor values for the resultant landscapes. The use of these sophisticated raster analyses allow me to explore how natural and cultural factors contributed to the cumulative changes in the Hasa landscape throughout the early metal ages.

<u>Statistical Methods</u>: I use a number of simple and well-known statistical methods to interpret temporal, spatial (i.e., landform- or location-based) and functional variations among the sites. The first method of the statistical testing is ANOVA, which is a powerful and widely used statistical application in testing the normality and visualizing how observations are distributed (Johnson and Berk 2000: 134-135). ANOVA focuses on the degree of variation in the dataset by comparing means between at least three groups (Johnson and Berk 2000:145) and it assumes equal variance in the sample and the

samples are independent (Johnson and Berk 2000: 135). Therefore, the null hypothesis in ANOVA is that there is no difference in mean values while the alternative assumes some level of variation (Johnson and Berk 2000: 146). The significance of the results is expressed in probability (p), which means that any result that is less than 0.05 is commonly accepted as significant for ANOVA results (i.e., the null hypothesis is rejected) (Johnson and Berk 2000: 145-146).

The second statistical tool I used in my research is the box plot (or box-andwhisker diagram), which is a convenient way to illustrate differences between groups of observations in data sets. The extreme observations that do not fit the general distribution pattern of data –i.e., outliers- as well as the symmetry and distribution of data are displayed (Johnson and Berk 2000: 93-94).

Using ANOVA and box plots in my analyses, I measured the degree of variance between variables either through time or among different groups. Although the variation in the mean values for each group of observation is a common alternative indicator of change, the mean is sensitive to outliers. Therefore, in my analyses, I combined data from box plots and histograms in order to ensure that outliers do not distort the general pattern. *Description of Analytical Methods Used for Answering the Research Questions*

<u>Tracking Environmental Changes through Time</u>: Environmental change is often the result of interplay between natural and cultural factors. Using GIS, the direction and magnitude of natural changes to the environment can be tracked and these can be quantified through statistical methods.

The first GIS analysis is the preparation of temperature and rainfall maps. The Hasa covers a large territory that extends between the steppe and the desert, making rainfall an important contributing factor for certain subsistence practices and social formations. High Resolution, Site-Specific, Macrophysical Climate Modeling (MCM) (Bryson and DeWall 2007) is a heat-budget model, which attempts to accurately identifying the mean centers of high and low sea-level pressure that determine the weather and wind systems at mid-latitudes along with the jet stream (i.e., a narrow corridor of very strong winds in the upper atmosphere) and Intertropical Convergence (e.g., the boundary between the northern and southern hemisphere surface air) (Barry and Carleton 2001; Bryson and DeWall 2007). Using Bryson's MCM, it is possible to mathematically estimate meteorological parameters such as precipitation, temperature, evaporation and stream discharge for as early as 40,000 BP, at 100-year intervals on the basis of the meteorological data between 1960 and 1990 from weather stations around the Hasa (Bryson and DeWall 2007: 4, 8, 33-44). The results of the MCM at individual weather station localities have been extended over continuous landscapes by regression modeling as part of the MEDLAND Project (Barton, Ullah and Mitasova 2010). MCM data are also used in the previously mentioned GRASS modules that compute the landscape evolution. MCM results for the Hasa between 3500 and 700 BC, available through the MEDLAND Project, not only reveals how basic climatic parameters oscillate spatio-temporally but more importantly they provide the palaeoenvironmental context to interpret the periodic changes in the settlement systems.

A second GIS analysis is the preparation of the watershed maps. using DEMs. GRASS GIS uses topographic data derived from DEMs –such as elevation, direction and angle of slopes– in order to estimate the direction and quantity of water from rainfall flowing across a surface. Such analysis is used to identify potential streambeds as well as watersheds of various sizes. Information from such hydrological analysis of watersheds can also aid in the calculation of sediment erosion or deposition rates at a given site.

These geospatial data provide detailed, spatially explicit information about the physical environmental and its changes in the Hasa through time. Watersheds are important resources in an environmentally marginal place like the Hasa; using these maps, possible water sources for sites can be identified through buffering (see below). Also, combining modeled precipitation and temperature data with the watershed data can help to identify the lack or presence of critical resources in the Hasa relevant for temporal changes in site locations. These data can help illustrate how climatic factors may have contributed to the changes in fluvial regime of the Hasa drainage through time.

Finally, it is possible to model long-term landscape evolution in the Hasa using the 'r.landscape.evol' module, developed by the MEDLAND research team. This module, for GRASS GIS, can calculate the effects of parameters such as rainfall (Rfactor), soil erodibility (K-factor), land cover (C-factor) and slope on the rate and location of surface dynamics (Barton, Ullah and Mitasova 2010). These variables are translated into raster maps where cumulative and annual changes in erosion-deposition, elevation, and soil depth can be estimated for time intervals specified in the analysis. These maps illustrate the changes in the landscape across the research area and can be queried for the results at any specific location. The results of the landscape change maps can then be interpreted in order to explain the role and significance of natural factors for environmental change in the Hasa.

The statistical aspect of tracking environmental change through time involves plotting the centennial temperature and rainfall data for each period between Chalcolithic to the Iron Age. The temporal changes in these climatic variables are displayed using box plots to demonstrate change through time. Also, the changes in these variables in relation with landforms, site functions and site complexity (i.e., the calculated number of features) can help identify possible relationships among them.

<u>Terrain Characteristics of Site Distribution</u>: In order to test the expectations discussed earlier, GIS and statistical methods are used to correlate elevation data with precipitation and temperature variables, which are crucial for interpreting the range and intensity of anthropogenic activities. The results also indicate whether the environmental conditions in certain elevation ranges actually meet the expectations in terms of resource diversity and availability.

The second component of the GIS analyses is defining the landscape elements, which are used to scale landform occupations. Using DEMs, there are several ways of accomplishing this task in GRASS GIS. The module 'r.param.scale', a raster operation for analyzing terrain parameters, can calculate various curvatures as well as slopes of the landscape in grids of user-defined size (e.g., 9-by-9 cells) in order to map and calculate area, cell counts, total percentages of flatlands, pits, ridges, peaks and valleys. This method is more useful in identifying landscape elements other than peaks or prominent

points across the landscape. The module 'r.prominence' on the other hand, uses a different approach in landscape analysis and is more efficient for identifying peaks. This module analyses DEM in a window, whose radius is user-specified to calculate the difference between the central cell and its neighbors in terms of elevation. Since elevation is the focus of analysis, the resulting map illustrates prominent locations (i.e., peaks) across the landscape. It is possible to collect statistics on such analytical maps, including the area, cell counts and total percentage of each landform. Using this information, the site distribution on each landform can be scaled in terms of frequency and size (see the paragraph on statistical applications in this section).

Watershed analyses in GIS platform, described in the previous section, can also be used to test the elevation range hypothesis from the perspectives of availability of water, proximity to year-round, reliable sources of water as well as the landscape stability (when combined with maps of soil accumulation or loss in a zone). Additionally, the proximity of sites to water sources can be evaluated by creating buffer zones around stream networks, prepared in the watershed analysis. It is possible to superimpose a vector map of sites on the buffer raster map and collect the distance of each site (in meters) to the nearest stream or spring. This information is important in interpreting the site function, size and internal complexity aspects of settlement patterns.

Finally, using 'r.agropast.extensive' script in GRASS GIS, the scale of human impacts in certain elevation ranges can be tested. This module calculates a "catchment area" where agricultural and pastoral activities take place. The size of pastoral catchment area is usually kept large since herd animals such as goats can graze far from villages. Detailed information from ethnoarchaeological and archaeological work can be used for the calculation of the agricultural catchment area. For example, various studies suggest that in the Near East, farmers need roughly 1.36 ha. of fields per person (for a review of estimation methods, see Zorn 1994). Using the number of habitation units at a site and multiplying this number by four (Zorn 1994), a population estimate for each site can be reached. Based on the population estimate for the site, the agricultural catchment can be calculated using 1.36 as coefficient. The next step in the process is to exclude potentially difficult locations around the site from agricultural activity, which is done by specifying a threshold for the slope value (i.e., 20 degrees or higher for the Hasa since the settlement density drops sharply on such terrains). The size of the agricultural catchment also needs to be adjusted for possible fallow practices. If, for example, 20% fallow is allowed, this means that each farmer needs an additional land every fifth year for farming. Therefore, the agricultural catchment must be five times larger. The module mimics the land use patterns of agropastoralists and calculates scale and extent of changes to the land cover around the site. Since this module was originally developed for Wadi Ziqlab in northern Jordan, it was necessary to change the range of land cover classes in order to account for differences in temperature, precipitation, and types of vegetation in the semi-desert landscape of the Hasa. Therefore, I rearranged the land cover classes to start with bare land and gradually changing into grasslands and then evolving into a land cover, which is composed of grass and small trees within a 50 year period. The associated c-factor values were also reset: 0.1 for the bare land, 0.05 for grassland, and 0.09 for grass with small trees. The resulting maps can then be interpreted to explain the factors that bring human

induced (i.e., anthropogenic) landscape modifications, based on such alterations. These maps also test the environmental stability of terrain at a particular elevation through out the periods in addition to displaying the zones of the drainage that groups may avoid or frequent depending on the resource availability. Combined with 'r.landscape.evol' maps, the results here potentially provide a more complete picture of which factors (i.e., natural or cultural) affected the landscape in what way.

Statistical testing of the elevation distribution hypothesis involves scaling and ANOVA of settlement data to untangle relationships among elevation, site function and internal complexity, temporally and spatially (i.e., from one landform to another). The landform data were scaled, in terms of frequency and area, in order to understand whether certain landforms show preferential settling and/or certain site types occupy certain terrains. Additionally, site density (the number of sites per square kilometer) for each period and for each landform was calculated to examine spatio-temporal oscillations in site locations. The slope and aspect factors of the Hasa landscape were also analyzed to explore possible temporal and/or functional trends in the dataset. The results of GIS-based watershed analyses (e.g., sediment accumulation rates at each site, site distances to streams) were compared according to site function, periods of occupation and the number of features at sites.

The second dimension for interpreting temporal changes in elevation distribution and how the settlement patterns change are in relation to signatures of hierarchy and heterarchy. Following the discussion in the theory chapter and earlier discussion in this chapter, the hierarchy is defined as a factor of social fusion, which increases site type diversity, allows emergence of larger and complex (i.e., multi-featured) sites that become political and economic centers in a settlement system. The identification of hierarchic social organizations in the archaeological record usually involves analyses of site size at a temporal scale. The presence of few but significantly larger settlements complemented by numerous smaller settlements suggest a hierarchic organization of the settlements (Figures 84, 85 and 94), reflecting a complex social organization. In the context of the Hasa, identification of hierarchic settlement systems is difficult due to apparent low population and settlement density. However, the IA settlements can be tested using the scale-free network concept. As a comparison with the IA, I use the EB I-III settlement data. This allows me to compare the two most densely settled periods of the early metal ages in terms of development of hierarchic social organization from the perspective of settlement systems. The testing involves the rearrangement of settlement data into groups/bins of set size. Then, the number of sites in each group is recorded. When the number of sites and site size are plotted at log-log scales, a sloping down regression line verifies the expectations of settlement –hence, social–hierarchies (compare Figures 94 and 95).

<u>Analyzing Conflict and Exchange:</u> I analyze changes in size (i.e., square meters) of military sites throughout the early metal ages in the Hasa, in order to assess the security concerns. Sizes of towers and forts are compared to each other through time in order to test whether expected changes in size took place. An additional dimension in this analysis is the comparison of forts and towers of the same period in terms of size and complexity

to verify if the expected functional differences between these military site types can be identified using these variables.

Assessing temporal changes in terrain preferences of military sites involves thematic mapping of these sites (i.e., the GIS map that color-codes military sites from different periods) and collecting the terrain information for each site, on 'r.param.scale' maps (as mentioned in the previous section), and then subjecting these variables to ANOVA in order to seek patterns that might have changed at temporal scale. A similar approach is taken to evaluate the distance of military sites to the nearest village in EB I-III and IA using GRASS GIS. These values are then analyzed in ANOVA and box plots to test assumptions about the relationship between military sites and large economic sites.

Evaluating the expected changes in settlement locations during the EB IV-LB period requires the analysis of the Hasa landscape in GIS platform using 'r.prominence' (explained in detail in the previous section) to identify "peaks" in the Hasa drainage. This map is then used to test the assumptions about the weight of security concerns on the settlement location during the abandonment phase and comparing it with site distributions of other periods.

The assessment of temporal changes in the mission of military sites (i.e., protecting sites vs. protecting economic infrastructure such as trade routes) is possible by preparing 'r.walk' maps for military sites. In this module, each military site from a period is taken as the origin and distances of travel from individual military sites to any location on the landscape is calculated using the slope as a factor of cost of travel. Then, I limit the travel time to one hour (3,600 seconds) on the landscape in any direction from each

military site at a given period. Once this procedure is repeated for each period, it is possible to compare the distribution of military sites in relation to the distribution of other sites. These maps can, then be used to test whether military site distribution has a "networked" approach on the landscape, how much of the Hasa and what percentage of sites are covered, whether sites that fall outside the one-hour walking distances have a certain pattern.

Comparative analysis of EB I-III and IA settlement patterns involves thematic mapping of all sites from these periods, by function. These maps are then analyzed with respect to settlement densities and size differences on different terrain types in order to test the idea of "peripheralization" of the Hasa during the IA by assessing whether the settlement systems reached their most extensive scale during the IA suggesting the presence of an external political power in the region. A similar approach is taken for the distribution of the military sites from these periods. Using a thematic map of military sites from these periods and combining this information with other analyses in this section, the assumptions about peripheralization and its reflections in the military site patterning are assessed.

Testing the role of trade and exchange in the Hasa settlement systems during the early metal ages also depends on GIS-based analyses. As the first step, 'r.walk' and 'r.drain' modules of GRASS GIS are used to identify the least-cost paths in the west Hasa on N-S axis. 'r.walk' is the module that uses the algorithm for calculating the costs of walking over a terrain, based on energy expended (Neteler and Mitasova 2008:139). The module also calculates the duration of travel in seconds from one point to another on the

landscape. Using cost-distance maps created in 'r.walk', 'r.drain' calculates and maps the least-cost path between two specified points. These show optimal routes between the destination and the origin of trip (Neteler and Mitasova 2008:138).

Testing the predictions about the relationship between trade routes and settlement density, diversity and complexity is done by combining GIS and statistical applications. Once the least-cost paths are identified in the west Hasa, one kilometer buffers are formed around these routes in GIS platform using 'r.buffer', as explained in the previous section (see Figure 90). The width of buffer can be specified in meters. Using ANOVA, the sites that are in the buffer are subjected to comparison with similar sites outside the buffer for their levels of internal complexity. The number of sites in the buffer is used to calculate the density of settlement within the buffer and this is used as a comparative index to measure the assumed impacts of exchange in the Hasa settlement systems. As a test case, I digitized the path of Roman Via Nova with the assumption that the path was also viable for travel in the IA. The analytical procedure described above was applied to sites around Via Nova. At this stage, a complementary GIS analyses is the identification of view sheds. In GRASS GIS, using the line of sight analysis, it is possible to identify how much of the landscape is visible at a certain height above the ground from each site. Using this module, I prepare view shed maps for military towers, using 5 meters as the height above the ground. Then, for each period, I combine view sheds from each military site. Overlaying these view sheds on the sites and trade routes, a general idea of which parts of the Hasa landscape have been given priority in terms of defense can be obtained.

This information then is used to identify whether certain trade routes fall in view sheds of more than one military site.

This chapter presented the kinds of data available, the research questions and the analytical methods employed in my research. The following two chapters focus on presenting the results of GIS and statistical analyses for the temporal changes in settlement patterns, the critical environmental factors such as precipitation, temperature and elevation as well as how the inhabitants responded to such changes (i.e., in terms of social organization), how the landscape evolved with (i.e., 'r.agropast.extensive' model) and without ('r.landscape.evol') anthropogenic impacts.
Chapter 5

THE TEMPORAL PATTERNS OF CHANGE IN THE SETTLEMENT SYSTEMS AND IN THE ENVIRONMENT OF THE HASA

Introduction

This chapter focuses on presenting a summary of the results for the long-term cycles of abandonment – resettlement and changes in the environment of the Hasa during the early metal ages. Consequently, the presentation and discussion of the results center on the first group of research questions (i.e., temporal patterns of change in site diversity, landforms occupied, changes in settlement density, elevation and site complexity as well as temporal changes in critical environmental factors such as precipitation and water accumulation) presented in the previous chapter. The number of variables that can be presented in a graph is limited. Therefore, I grouped them when possible. Each graph contains percentage and count information. For the ANOVA charts, the (p) value is provided in the label of the figure and when necessary, coefficient of variation (CV), median and the mean of the distribution are provided. Unless otherwise stated, a temporal comparison chart is composed of four different charts for Chalcolithic (a), EB I-III (b), EB IV-LB (c) and the IA (d).

General Temporal Distribution:



Figure 5. Temporal distribution of the Hasa sites between Chalcolithic and the Iron ages.

The frequency of sites (n=335), and therefore population density in the Hasa, shows two major peaks: during the EB I-III (n=88) and the IA (n=186). The sharp decline in the EB IV-LB (n=24) is noticeable, which lasts about 1,100 years. The IA site frequency suggests a sudden and exponential increase of settlement activity in the Hasa. Figure 6 (below) illustrates the scale of changes in settlement frequency after the number of sites is scaled by unit time (i.e., the number of centuries in each period). The patterns suggest that the increase from the Chalcolithic to the EB I-III is gradual and has an autochthon nature (i.e., slow and gradual increase in the number of sites). The scale of change in settlement frequency in the EB IV-LB period clearly reaches the level of abandonment both in terms of scale and length of time. The sudden flare-up of settlement activity in the IA supports the idea that Hasa becomes a periphery in this period, possibly by the Moab. The socio-political aspects of the IA settlement systems are discussed in detail in the next chapter.



Figure 6. The line chart showing the changes in density of settlements and their percentages after the settlement frequency is scaled by unit time (i.e., the number of centuries in each period)

| Site Category | Type of Sites Included | Abbreviation in the Text | |
|---------------------------|---|--------------------------|--|
| Large Economic | Villages | LGECON | |
| Cave | Caves and rock shelters | CAVE | |
| Military | Forts and towers | MLTRY | |
| Activity-Facility | Aqueduct, caravansary, grinding, lithic and sherd scatters, mill, platform, quarry, terraces and camps | A_F | |
| Small Economic | Domestic clusters, enclosures, farms, hamlets, structures and structure complexes | SMECON | |
| Burial | Cemeteries and tombs | BURIAL | |
| Ideological | Hermitage, petroglyph and temple | IDEOLOG | |
| Undifferentiated Walls | Rock alignments, stone circles and walls | UNDIFF | |

Overall Site Type Distribution and Temporal Patterns:

Table 6. The classification table of the Hasa site types into categories. The abbreviations used in the dissertation are also provided in the table.





There are thirty site types based on function. The sites are grouped under eight broader functional categories to avoid redundancy (Table 6). Small economic sites have the highest representation among the Hasa suite of sites. Along with this type, activityfacility, large economic and military sites form the bases of my analyses. The temporal distribution of site types, from Chalcolithic through the IA is shown in Figure 8.



Figure 8. The temporal distribution of site categories mentioned in Table 6.

Site type diversity is the lowest in the Chalcolithic period with most sites heavily focusing on food production and processing. The diversity significantly increases with the EB I-III, which has the full suite of sites for the first time. The diversity does not decline significantly during the EB IV-LB. However, considering the drop in the frequency of sites and population, it is clear that the Hasa goes under major abandonment. The IA represents a major change in the Hasa settlement systems. The site frequency almost doubles from the EB I-III period. The increase in the frequencies of large economic and military sites is noteworthy in this period.

The next group of charts (Figures 9-12) analyzes the predominant landform preferences and site types on the most popular landforms in each period. The landform data is presented separately (Figures 33-37 and 40-43).

Chalcolithic:



Figure 9. The Chalcolithic period distribution of all site types on landforms (a); and the frequency of different site types on level terrains (b), ridges (c), saddles (d) and valleys (e).

The Chalcolithic sites are on diverse landforms (Figure 9a). This diversity, differences in elevation and availability of diverse resources on ridges and in valleys may have been important in making strategic decisions while choosing site locations. Such decisions may point to selective use of resources. The small economic sites and activity-facility sites do not indicate clear preferences for landforms (Figure 9b-e) whereas military sites seem to have favored saddles, which can be attributed to defensive tactics.

Early Bronze I-III:



Figure 10. The EB I-III period distribution of all site types on landforms (a); and the frequency of different site types on level terrains (b), ridges (c), saddles (d) and valleys (e).

The variety of landforms occupied does not change during this period. Valleys maintain their popularity, partly due to the growing significance of terrace agriculture in this period (Figure 10a). Although the frequency and density of sites increase in the Hasa, the EB I-III sites are not associated with particular landforms since each landform shows increase in site diversity (Figure 10b-d). This may suggest the emergence of a complex

economic system that relies on more organized (i.e., planned and coordinated), extensive use of resources and establishment of exchange systems, overseen by large economic sites (i.e., villages). Such economic organization indicates a major shift from the Chalcolithic economic organization. Extensive economic organization and increased site type diversity indicate that competition and security are not significant social issues and the society aims for production and largely internal exchange of goods.

Early Bronze IV – Late Bronze:



Figure 11. The EB IV-LB period distribution of all site types on landforms (a); and the frequency of different site types on level terrains (b), ridges (c), and valleys (d).

Fewer sites are settled in the Hasa from the late Early Bronze to the end of the Bronze Age. The overall pattern in this period is one of declining settlement activity and site diversity across landforms when compared to the previous periods (Figure 11b-d). Although this pattern may be an issue of sample size, the variety of terrain used declines slightly –peaks are not settled– (Figure 11a) from the previous periods. Similar to the Chalcolithic, the settlement patterns of this period suggest low intensity but selective exploitation of resources, which may also raise the issue of locating sites in relation with some strategic factors. The valleys almost entirely consist of small economic sites (Figure 11d), which can be directly attributed to reduced availability of water (i.e., lower precipitation, channel down cutting), as indicated by paleoenvironmental records and the climatic modeling used in this research (see Figure 56). The continuing popularity of ridges may lead to the supposed competition among tribes for resources.

Iron Age:



Figure 12. The IA period distribution of all site types on landforms (a); and the frequency of different site types on level terrains (b), ridges (c), saddles (d) and valleys (e).

The diversity of terrain types increases in this period (Figure 12a). The main difference between the EB I-III and IA settlements is the doubling frequency of sites on these landforms during the latter. Although the settlement density remains light, the level terrains are resettled after the EB IV-LB abandonment and the site type diversity is high (Figures 10b, 11b, and 12b). The site type diversity increases in valleys and catches up

with the EB I-III levels (Figures 10e and 12e). The sites on ridges on the other hand, show slightly higher diversity than the EB I-III period (Figures 10c and 12c). The IA landforms have roughly the same composition and frequency of sites with the EB I-III, which suggests that the extensive nature of the economic organization continues in the IA. The increase in the frequency of villages deserves attention, which may be the result of the first territorial state formations of Moab and Edom as well as the Arabian caravan trade.

The temporal patterns for the most common site types can be summarized as follows. The small economic sites indicate that this type of site remains common on variety of landforms throughout the early metal ages but especially during the EB I-III and IA, the diversity of landforms increase. A similar pattern emerges for the activity-facility sites, which show less diverse patterns of landform preference, especially for the EB IV-LB period but this can be an effect of sample size. In general, however, these sites follow the overall pattern and increase diversity of landform in phases of population increase and settlement expansion. The military sites show limited variation in terms of landforms they occupy. They are usually on saddles or ridges and this pattern may be the result of function of these sites and the military tactics used. The large economic sites, which emerge only during the EB I-III and IA, show increase in landform diversity in the IA (e.g., incorporation of plateaus in addition to traditional choices of valleys and ridges), which supports the increasingly extensive nature of settlement systems.



Figure 13. The ANOVA chart showing the temporal patterns of change in the number of calculated features at sites. The results show that the temporal change is not significant (p=0.112).

The internal complexity is generally low in the Chalcolithic; the mean is 2.72. Although the frequency of sites is quite low, there are few extremely complex sites. The internal complexity of EB I-III sites remains low; the mean is 2.04. Considering the increase in site type diversity and frequency across the Hasa landscape, low internal complexity supports low intensity (i.e., extensive) land use in the Hasa. However, it is important note that the complex sites of this period have more features than the Chalcolithic, which may be a result of villages. The internal complexity declines significantly in EB IV-LB: the mean is 1.16. Such low level of internal complexity agrees well with large-scale abandonment, massive depopulation and substantial decline in economic activities from the previous period as subsistence possibly focuses more

heavily on pastoralism. The IA sites return to EB I-III levels with a mean of 2.44. Considering other similarities in settlement diversity and landforms utilized discussed above, both EB I-III and IA represent phases of higher economic investment in the Hasa through extensive settlement activity (also, see Figure 40-43).





Figure 14. 10-meter resolution digital elevation map (DEM) of the Hasa draped over shaded relief map, showing the Chalcolithic settlements.

The Chalcolithic sites are densely clustered in the upper (i.e., east) Hasa, where the landscape is not much dissected and access to critical resources, such as water may have been relatively easier within a zone (Figure 70). Considering the low site diversity and low population density of this period, which is heavily oriented towards food production (i.e., small economic, activity-facility and military sites), it is possible to suggest that the focus of settlement in this period is mainly self-sustaining activities

(Figure 9, Tables 5-6).

The Early Bronze I-III Period Sites (n=88):





The spatial distribution of sites in this period as well as the emergence of the fullsuite of the early metal age sites (Figure 7), along with increasing site frequency, suggest that the EB I-III inhabitants of the Hasa adapt an extensive economic organization and utilize the existing landforms for more diverse set of activities (Figure 10b-d). Although the settlements maintain their strong presence in the upper Hasa, this is the first period when there is significant settlement activity in central and lower (i.e., west) Hasa. This pattern provides additional support to the idea that the economic organization of this period is extensive and organized under villages, which suggests a change in the nature of production from self-sustenance to producing for local exchange (Tables 5-6).

The Early Bronze IV-Late Bronze Period Sites (n=24):





The spatial distribution of sites during the abandonment phase has significant implications for the changes in the economic organization. The upper Hasa is largely void of settlement activity. The axis of settlement has shifted to the west-central drainages and this part of the Hasa shows great environmental variations, especially in terms of elevation (see Figure 70). The reduced diversity of site types (i.e., predominantly small economic sites) represents a reversal in the economic trend from the previous period to the self-sustaining. Although this seems to be parallel with the Chalcolithic, the subsistence pattern in this period is more likely to be oriented towards pastoralism (Tables 5-6), as movements across different landforms and elevation ranges suggest (Figures 11 and 70).





Figure 17. 10-meter resolution digital elevation map (DEM) of the Hasa draped over shaded relief map, showing the IA settlements.

The IA spatial distribution of sites reveals a striking pattern in terms of sudden and exponential increase in the density of settlements as well as the range of activities and wide variety of landforms utilized (Figure 12). This is the second period when all site types of the early metal ages can be found in the Hasa. Two core areas of settlement are visible from the above map. The upper Hasa has been the choice for small economic and activity-facility sites whereas the villages are clustered on the southern plateau. The military sites show sporadic –but meaningful– distribution (Figure 70). Increased site diversity and expansion of economic activities on various landforms represent the return of the extensive economic organization in this period (Tables 5-6). However, the nature of this process and the brevity of the time that this settlement pattern takes to mature will be discussed in the following chapter for its social and political implications.

The distribution of sites according to cultural periods, the temporal composition of site types, and the levels of internal complexity point out that the settlements in the Hasa start as low density, low complexity system that undergo a major transformation in the EB I-III. This developmental phase is abruptly interrupted in EB IV-LB and sudden change takes place through out the IA; population and settlement density increases exponentially.

Before exploring the reasons for these events, it is necessary to understand the composition of the Hasa topography. The geological and environmental particulars of the Hasa have been discussed in the previous chapters. The elements of the Hasa landscape are discussed in the following section.

The Overview of the Hasa Topography

The topography of the Hasa (i.e., the slope characteristics, landscape features, the prominent places on the landscape, watersheds) is important to consider in my research as they contribute to the development and the evolution of the settlement systems in the area. In each section, after an overview, I present scaling data about temporal changes in settlement (i.e., according to slope and landscape features) in order to illustrate temporal oscillations.

The Slope Map:



Figure 18. The slope map of the Hasa draped over shaded relief map. The legend shows colors of the slope categories described in Table 8. The degree of slope increases especially around As-Safi, in the lower (west) Hasa.

| Slope | Range of | | | Square | Percent |
|----------|----------|--------------------|------------|------------|---------|
| Category | Degrees | Category Name | Cell Count | Kilometers | Cover |
| 1 | 0 to 9 | Flat | 6,309,625 | 630,776 | 64.89 |
| 2 | 10 to 19 | Slight Slope | 2,392,614 | 239,191 | 24.60 |
| 3 | 20 to 29 | Medium Slope | 733,677 | 73,346 | 7.54 |
| 4 | 30 to 39 | Medium Steep Slope | 219,829 | 21,976 | 2.26 |
| 5 | 40 to 49 | Steep Slope | 53,929 | 5,391 | 0.55 |
| 6 | 50 to 59 | Very Steep Slope | 11,775 | 1,177 | 0.12 |
| 7 | 60 to 80 | Extreme Slope | 2,833 | 0.283 | 0.03 |

Table 7. The color, range of degree, description, cell count, area and percentage cover of slope categories in the Hasa slope map (Figure 18). The total area of the Hasa drainage is 972 square kilometers.

In arid environments like the Hasa, due to the combined lack of vegetation, erratic rainfall and human impacts, thin soil layer can be easily eroded if either the majority of landscape consists of sloping land or most of the human activities take place on slopes. The Hasa landscape includes large areas that are either flat or are slight slopes (89.49%). Figure 18 clearly illustrates that the lower Hasa has most of the sloping terrain in the area whereas the plateaus are common on the North Bank and to the south. The land in between (i.e., central drainages) shows a mixture of slope categories. This section of the Hasa becomes significant with EB I-III and IA settlement expansion across the drainage when extensive economic organization requires use of diverse resources and landforms. The growing significance of the west-central drainages in the time of abandonment on the other hand, can be attributed to changing economic perspectives (i.e., the shift from agropastoralism to pastoralism in EB IV-LB) and hence the necessity to settle in parts of the Hasa with greater environmental diversity (i.e., for vertical movements on the landscape), especially in terms of elevation (Figure 70). As Table 7 shows, only 10.5% of the land in the Hasa has slopes higher than 20 degrees. Based on the results from Figure 19 (below), 15.3% of sites are on these slope categories.



Figure 19. The number and percentage of sites in each slope category.

| Category Name (n) | Slope Area (sq km) | Percentage Cover of Category | Site Density (site/sq km) | Per cent of area occupied |
|----------------------------------|-----------------------|------------------------------------|------------------------------|---------------------------|
| Flat (177) | 630.77 | 64.89 | 0.2806 | 0.06 |
| Slight slope (105) | 239.19 | 24.6 | 0.4389 | 0.09 |
| Medium slope (38) | 73.34 | 7.54 | 0.5180 | 0.04 |
| Medium Steep slope (9) | 21.97 | 2.26 | 0.4096 | 0.04 |
| Steep slope (4) | 5.39 | 0.55 | 0.7421 | 0.06 |

Scaling of Settlement Data with Slope Categories:





Figure 20. The bar chart showing the site density on slope categories from Figure 19 and Table 8.

The results of site density calculations (Table 8 and Figure 20) suggest that the site density remains low for the flat and slight slope categories, which have the highest frequency of sites but they also cover much larger areas (89.49% of the Hasa surface area). The site density for medium steep slope category is comparable with the slight slope but the site density is higher for medium slope and steep slope categories. A closer look at the sites from medium slope to the steep slope categories shows some interesting patterns.

The medium slopes –category 3 in Table 7– (Figure 21) become highly popular in the IA –even if some earlier presence is evident– and although site type diversity is high the small economic sites make up the majority. The IA sites dominate the distribution across the elevation bands, whereas the earlier sites remain in lowlands generally. The internal complexity level of sites shows greater variation.



Figure 21. The distribution of all sites on medium slopes according to period (a), site types (b), elevation (c), and the number of calculated features (d).

Medium steep slopes –category 4 in Table 7–are equally popular in EB I-III and IA (Figure 22). The site type diversity is much lower and the small economic sites dominate this group. The sites in this slope category show diverse temporal associations and the EB I-III sites dominate the distribution. These sites are located between 800-900 masl whereas the IA sites are in 700-1,000 masl. The internal complexity level is significantly low and sites are more uniform in their level of complexity.



Figure 22. The distribution of all sites on medium steep slopes according to period (a), site types (b), elevation (c), and the number of calculated features (d).

Steep slopes –category 5 in Table 7– are mainly settled in the EB I-III and their popularity remains low in the later periods (Figure 23). The site type diversity is much reduced. The small economic sites constitute the majority and the remainder is activity-facility sites. The EB I-III sites are found above 1,000 masl and the only IA site is at 400 masl. The sites display low levels of internal complexity.



Figure 23. The distribution of all sites on steep slopes according to period (a), site types (b), elevation (c), and the number of calculated features (d).

The distribution patterns above suggest that in the EB I-III period, the inhabitants of the Hasa move in to areas where slopes are steeper (i.e., especially medium steep and steep slopes) and populate them mainly with small economic and activity-facility sites. Such steep slopes are not popular in the Chalcolithic and show very light settlement activity in the abandonment phase. This EB I-III expansion on steeper slopes can be attributed to the movement of sites within a narrow elevation band on the landscape (Figures 22c, 23c and Figure 70), which indicates that the settlement expansion of this period is horizontal (i.e., making use of wider variety of lands while remaining within a narrow range of elevation). These can be partial results of the climate regime of this period (Figure 55b), when it was warmer and wetter than the later periods. The medium

slopes (20-29 degrees) show some settlement activity from the Chalcolithic to the EB IV-LB but the real change comes with the IA. Considering the IA histogram in the Figure 70 –as well as Figures 21c and 22c– and the high diversity of site types from this category, it is possible to suggest that the settlement expansion of the IA is mostly vertical –due to the heavy focus on pastoralism–. In other words, the IA inhabitants choose settlement locations at different elevation bands (i.e., multi-modal distribution discussed below) while keeping slope preferences well defined, which represent a change from the EB I-III settlement expansion. Therefore, EB I-III and IA methods illustrate two different ways of extensive economic organization on a landscape.

The plotting of mean site size with the number of sites on slope categories (Figure 24) reveal that although site density is lower in flat and slight slope groups, the sites tend to be significantly larger. This supports the observations above about the sloping lands being primarily targeted by small economic sites in phases of settlement expansion in the Hasa.



Figure 24. The bivariate analysis ($R^2 = 0.86$) indicates relationship between slope category and mean site size. The ANOVA table suggests change in mean site size according to slope categories (p=0.0222).

| Period | Predominant Slope Category and Site Density (site/sq km) | SMECON, density | A-F, density | MLTR, density | LGECON, density |
|--------------|---|--|----------------------------|------------------|----------------------------|
| Chalcolithic | Flat, 0.0285 | Flat, Slight slope, 0.0172 | Flat, 0.0063 | Flat, 0.0047 | - |
| EB I-III | Flat, 0.0760 | Flat, 0.0459 | Flat, 0.0158 | Flat, 0.0079 | Slight slope, 0.0250 |
| EB IV-LB | Slight slope, 0.0459 | Medium, Slight slopes, 0.0351 | Slight slope, 0.0083 | Flat, 0.0015 | - |
| IA | Flat, 0.1648 | Flat, Slight slope, 0.0804 | Flat, 0.0206 | Flat, 0.0206 | Flat, 0.0475 |

Table 9. The summary table showing the most common slope category in each period, the slope preferences of each site type in each period and associated site densities.

The summary of temporal patterns in terms of general slope preference for each period as well as the site type-based patterns is provided in Table 10. This table also provides the site density figures on slope categories. The predominant slope category in all periods of the early metal ages in the Hasa has been flat lands –make up 64.89% of the Hasa surface area– and the site density replicates the overall changes in settlement systems (i.e., settlement expansion and contraction, population increase and depopulation). The only exception to this is the EB IV-LB period, when slightly sloping lands are more popular. Figure 25 (below) illustrates these temporal changes.



Figure 25. The bar chart showing site densities on the predominant slope category (i.e., flat) between the Chalcolithic and the Iron Age. The scale and direction of changes mimic the overall site density and temporal changes in settlement patterns in Figure 5.

The changes in slope preferences for each major site type can be summarized as follows. The small economic sites show greater diversity through time for their slope preferences (Figure 26), in comparison with other site types. Flatlands and slight slopes are preferred before the large-scale abandonment. During the EB IV-LB, these sites move to sloping lands, which can be related to the increasing emphasis on pastoralism. During the IA flat and slightly sloping lands are popular again. These oscillations between flatlands and slopes can be part of fine-tuning strategies of the settlers, who face with different climatic challenges in every period and adjust the type and intensity of subsistence patterns accordingly. The lack of consistency in terms of types of land characteristics (i.e., periodically changing the location of sites with respect to changing environmental conditions) and predominantly low complexity of sites throughout the early metal ages provide further support for the absence of intensive economic systems.



Figure 26. The distribution of all small economic sites in each period. The numbers on x-axis are the slope category numbers provided in Table 7.

The activity-facility sites show greater predictability, with the exception of the EB IV-LB, they are generally on flatlands (Figure 27). This is expected given the fact that their functions (i.e., food processing, public facilities) require easier access by the inhabitants. The change in the abandonment phase agrees well with the patterns of small economic sites shown in Figure 26c.



Figure 27. The distribution of all activity-facility sites in each period. The numbers on x-axis are the slope category numbers provided in Table 7.

Regardless of the period, military sites always prefer flatlands (Figure 28). Although this is unexpected given the fact that sloping lands are easier to defend, this must be further evaluated within the context of each site's location and function (i.e., what was that particular military site protecting?), which is discussed in the next chapter.



Figure 28. The distribution of all military sites in each period. The numbers on x-axis are the slope category numbers provided in Table 7.

The large economic sites start on slightly sloping lands in EB I-III and they exclusively occupy flatlands during the IA (Figure 29). This change may be partly related to the aridity mentioned earlier. However, the possible external relationships of the IA Hasa settlers, especially with the Moabite state on the Karak Plateau must be considered as an additional factor, which is discussed in the next chapter.



Figure 29. The distribution of all large economic sites in each period. The numbers on x-axis are the slope category numbers provided in Table 7.

The Landscape Features Through 'r.param.scale':



Figure 30. 'r.param.scale' map of the Hasa (moving window size 33 cells) showing the categories of terrain (10-meter resolution).

| Landform Category | Description | Cell Count | Square Kilometers | Percent Cover |
|----------------------|---------------|------------|----------------------|---------------|
| 1 | Level Terrain | 2,496,229 | 249.54 | 25.07 |
| 2 | Depressions | 489,997 | 48.98 | 4.92 |
| 3 | Valleys | 2,718,413 | 271.76 | 27.30 |
| 4 | Saddles | 793,832 | 79.35 | 7.97 |
| 5 | Ridges | 2,765,809 | 276.49 | 27.77 |
| 6 | Peaks | 551,078 | 55.09 | 5.53 |

Table 10. The color, description, cell count, area and percentage cover of each landform category in the Hasa based on Figure 30.

The elements and composition of the Hasa landscape are obtained from 'r.param.scale' module of GRASS, as explained in the previous chapter. The results of analysis indicate that level terrain, valleys and ridges make up majority of the Hasa landscape. The second category (i.e., depressions) in the Table 10 is combined with valleys in analyses below. The 'r.param.scale' module uses an algorithm that differentiates depressions/pits from valleys in the geological sense. In order to prevent redundancy and to provide more realistic estimates in the archaeological application of such data, I combined depressions and valleys under valleys. Saddles and peaks are not common in the Hasa but they are present. The identification of peaks and prominent spots on the landscape is more accurate if a different GRASS module is used due to the differences in algorithms as I explained in the Methodology chapter. The results are presented in a separate section in this chapter.



Figure 31. The number and percentage of the Hasa sites in each landform category.

The distribution of sites according to landforms is shown in Figure 31. Although the level terrain is one of the largest categories in terms of size, the frequency of sites on this landform is not significant. Valleys and ridges, which are equally significant in terms of size, have the highest number of sites. This points to the environmental and economic significance of these landforms (i.e., access to water, types of vegetation, subsistence practices), which make them more valuable than the level terrain. The saddles and peaks show much less settlement activity however, these landforms are significantly smaller in size.

| Landform Type (n) | Terrain Area (sq km) | Percentage Cover of Landform | Site Density (site/sq km) | Per cent of area occupied |
|----------------------|----------------------------|------------------------------------|------------------------------|------------------------------|
| Level Terrain (56) | 249.54 | 25.07 | 0.224 | 0.03 |
| Valleys (124) | 320.74 | 32.22 | 0.386 | 0.08 |
| Saddles (37) | 79.35 | 7.97 | 0.466 | 0.11 |
| Ridges (105) | 276.49 | 27.77 | 0.379 | 0.07 |
| Peaks (12) | 55.09 | 5.53 | 0.217 | 0.04 |

Scaling of Settlement Data with Terrain Features:

Table 11. The settlement density and the percentage of area occupied on each terrain type in the Hasa.


Figure 32. The bar chart showing the site density on landform categories from Figure 31 and Table 11.

The site density levels on level terrain and peaks are close, which is due to the small size of the peaks in the Hasa landscape. The settlement density remains high on the other three landforms. This is expected for valleys and ridges but saddles show the densest settlement and this is unexpected for a landform that is only the fourth largest in the area. A detailed examination of each landform in terms of temporal composition, site type diversity, elevation range and internal complexity levels are provided below.

The level terrains show continuous occupation from the Chalcolithic to the IA (Figure 33), however this landform becomes more significant in the IA. Although the small economic sites dominate the distribution, the level terrain has the highest site type diversity among the Hasa landforms. The diversity of sites increase in relation with the EB I-III and IA settlement expansion as part of the extensive economic use of landforms.

In other periods, the site diversity drops significantly. This landform is more common between 700-1,000 masl range, which contains the majority of the early metal age settlements. The EB IV-LB sites show wider spread and a similar multi-modal distribution is also observable in Figure 70. Finally, the continuous occupation and high site diversity do not contribute to the level of site complexity. The internal complexity generally remains low on this terrain except for the periods of denser occupation, when few sites become complex enough to have four or more features.





The valleys constitute one of the most densely settled landforms in the Hasa. Valleys are similar to level terrain in terms of continuous occupation from the Chalcolithic to the IA (Figure 34) and high site type diversity (i.e., the full suite of sites mentioned in Table 6). The periodic (i.e., EB I-III and IA) increase in site diversity is noticeable whereas in other periods the settlement activity is limited to small economic sites. The majority of valley sites are found in 700-1,000 masl range and sites usually display low complexity with the exception of phases of settlement expansion and extensive economic organization. The level of internal complexity shows parallel oscillations with the changes in site type diversity and declines significantly especially during the period of abandonment.



Figure 34. The distribution of all sites in valleys according to period (a), site types (b), elevation (c), and the number of calculated features (d).

Saddles cover smaller area in the Hasa, however in terms of site density, this is the most densely settled landform throughout the early metal ages (Figure 35). The settlement remains consistently low until the IA. Consequently, the apparent diversity of sites is a result of the IA settlement patterns, which introduce various other site types on this landform. Saddles, unlike valleys or level terrains, are associated with a certain site type –military sites– in the Chalcolithic, however in later periods it has diverse use. The sites in this group also show spread out distribution pattern in terms of elevation range. The presence of numerous sites above 1,000 masl is a result of the multi-modal elevation distribution of the IA settlements visible in Figure 70. The internal complexity of sites remains persistently low until the IA, when significant variations emerge.



Figure 35. The distribution of all sites on saddles according to period (a), site types (b), elevation (c), and the number of calculated features (d).

Ridges are the second largest landform in the Hasa, after valleys and they have the third densest settlement (Table 11). Like previous landforms, ridges also show continuous occupation from the Chalcolithic to the IA (Figure 36), however the increase in the IA settlement activity is not equally striking as on saddles. The site type diversity remains low in Chalcolithic and further drops in the abandonment phase but significantly increases in the EB I-III and IA. Consequently, this landform does not show association with a certain site type. Small economic sites tend to dominate this landform as in other landforms. Due to the geographic characteristic of this landform, the elevation of sites on ridges is generally above 800 masl. The greater variation in elevation on this landform is introduced by the sites of EB IV-LB. EB I-III and IA sites on the other hand show greater uniformity in occupying lands above 800 masl. The multi-modality of EB IV-LB and IA settlements is clearly visible in the elevation distribution here. Ridges are unusual in terms of site complexity. Except for the abandonment phase, in every period, there are few highly complex sites, which suggests certain economic and social significance of ridges to the inhabitants of the Hasa.



Figure 36. The distribution of all sites on ridges according to period (a), site types (b), elevation (c), and the number of calculated features (d).

The peaks have the smallest area in the Hasa landscape and the site density is among the lowest, along with the level terrain (Table 11). Peaks have been avoided during the abandonment phase but even in other periods the settlement remained sporadic (Figure 37). The IA increase in the settlements is not significant. Both Chalcolithic sites on this landform are activity-facility sites and in time, small economic sites replace these. Although peaks show the lowest site type diversity, it is also the only landform in the Hasa that shows clear association with a site type. The peak sites before the IA remain in the popular elevation band of 700-900 masl but with the IA, the settlements spread below and above this range. The internal site complexity starts to increase with the EB I-III –the time when small economic sites are established on this landform– but it drops in the IA.



Figure 37. The distribution of all sites on peaks according to period (a), site types (b), elevation (c), and the number of calculated features (d).

This brief survey of landforms illustrate that during the early metal ages in the Hasa, there is no clearly defined relationship between landform and a particular site type. The usual pattern is the dominance of small economic and activity-facility sites on landforms. The settlement activity increases – exponentially on some landforms– with the IA and this generally results with the introduction of diverse sites, while in earlier periods the settlement diversity remains low (for a discussion of temporal changes of landforms on the basis of site types, see Figures 40-43). In terms of elevation ranges, the distribution of sites across each landform mimics the multi-modality of the EB IV-LB and IA. Combined with the discussion for Figure 70, the changes in elevation ranges and increased site diversity on landforms during the EB I-III and IA support the extensive economic design of the settlement expansion phases. Such patterns also support the idea

of horizontal movement across the landscape during the EB I-III as opposed to the vertical movements in the IA, which may be traced back to the EB IV-LB. The complexity levels at sites show parallel oscillations with the changes in settlement density and diversity. As the settlement activity increases and as more site types are introduced, which usually starts with the EB I-III and increases in the IA, the site complexity changes and few highly complex sites emerge on each landform. This pattern agrees well with the changes in IA social complexity, organization, especially from the perspective of scale-free networks, which is discussed in the next chapter.

| Period | Predominant Landform and Site Density (site/sq km) | SMECON Landforms and density | A-F Landforms and density | MLTR Landf.s and density | LGECON Landforms and density |
|--------------|--|------------------------------------|---------------------------------|-------------------------------------|------------------------------------|
| Chalcolithic | Valleys and ridges, 0.0385 | Valleys and ridges, 0.0217 | Valleys, 0.0124 | Saddles, 0.0504 | - |
| EB I-III | Valleys and ridges, 0.1121 | Valleys and ridges, 0.0602 | Valleys, 0.0249 | Valleys and ridges, 0.0117 | Valleys and ridges, 0.0100 |
| EB IV-LB | Valleys and ridges, 0.0284 | Valleys, 0.0249 | Ridges, 0.0072 | Ridges, 0.0036 | - |
| ΙΑ | Valleys and ridges, 0.2042 | Valleys and ridges, 0.0803 | Valleys, 0.0342 | Ridges, 0.0397 | Valleys and ridges, 0.0502 |

Table 12. The summary table showing the most common landforms in each period and the landform preferences along with respective site density of each site type in each period.

The summary of landform use provided in Table 12 clearly points out the

economic, social and environmental significance of valleys and ridges in the Hasa

throughout the early metal ages. In each period, these landforms, covering 597.23 square

kilometers (61.44% of the Hasa surface area) maintain their popularity regardless of the changing social and/or economic dynamics in the area. Figure 38 (below) displays site densities on valleys and ridges through periods. The site density, consequently the significance, of the valleys increases from the Chalcolithic onwards. With the introduction of terrace agriculture in the EBA, these landforms are in demand. In the Hasa, valleys are important for the ease of access to water and proximity to mesic flora in the marginal environmental setting of the Hasa. The ridges on the other hand, offer a great alternative to valleys. They are located at slightly higher elevations, which make them attractive for other resources that may not be available in the valleys. Also, defending sites on ridges are easier. More importantly, when valleys and ridges are combined, they constitute a large area in the Hasa where water sources (i.e., either precipitation or water from streams) are more reliable than the rest (Figure 39).

The precipitation values in level terrains and peaks are comparable to the valleys and ridges. However, the level terrains lack the protection and resource diversity on ridges and in valleys. Peaks on the other hand do not cover large area in the Hasa. Consequently, settling densely on valleys and ridges has significant environmental benefits over other landforms. Based on the type of sites, Table 12 shows that majority of the most common site types prefer valleys and ridges, the changes in overall patterns are minor and temporary (e.g., the change in activity-facility sites from valleys to ridges in the abandonment and back to valleys in the IA). The large economic sites show greater stability in terms of their landform preferences, which can be attributed to the overall economic and political stability of these periods. The major temporal change in landforms takes place in military sites. As their density drops in the EB I-III and EB IV-LB, more popular landforms (i.e., valleys and ridges) are preferred for such sites. Although the military site density shows slight increase in the IA, the landforms do not change. Overall, these patterns suggest that the military sites gradually create a network of protection for the economic investments across the Hasa (see the section on the military sites in the next chapter).



Figure 38. The bar chart showing site densities on the predominant landforms (i.e., valleys and ridges) between the Chalcolithic and the Iron Age. The scale and direction of changes mimic the overall site density and temporal changes in settlement patterns and the temporal patterns for slope preferences in Figure 25.



Figure 39. The bar chart comparison of median precipitation values in each period based on the landforms described in Table 10.

The temporal distribution of small economic sites according to landforms (Figure 40) supports the extensive nature of the economic organization during the phases of settlement expansion. This group has always been the dominant type of settlement in the Hasa and as its significance increases in the EB I-III and IA –as part of the attempt to increase and diversify economic production– more diverse landforms are utilized as well as sites becoming more frequent on ridges. The abandonment phase patterns reflect the changes in the economic organization. The least frequently settled landforms of the previous period (i.e., saddles and peaks) along with ridges are abandoned in favor of level terrains and valleys. Such landform preferences agree well with the heavy nomadic focus for the social organization of the EB IV-LB that requires vertical movements across the

landscape (Figure 70). The IA rebound of small economic sites, both in terms of landform diversity and site density, reflects the general pattern in the Hasa settlement systems during the early metal ages.



Figure 40. The distribution of all small economic sites according to landforms in Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d).

The activity-facility sites show slightly more reserved distribution in their landform preferences (Figure 41). When evaluated together with small economic sites, the landform distribution of this group points out major overlaps, regardless of the period or the subsistence type in the Hasa. Consequently, the periodic settlement expansion and the impacts of extensive economic organization of these phases in terms of the diversity of landforms utilized are visible in this group of sites as well.



Figure 41. The distribution of all activity-facility sites according to landforms in Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d).

The military sites start with variety of landforms but a major change in the landform preferences takes place during the EB I-III, which continues and expands with the IA settlement systems (Figure 42). Although the frequent occupation of valleys and ridges is expected due to their popularity with small economic and activity-facility sites, the establishment of a security network and how it functioned are addressed in greater detail in the next chapter.



Figure 42. The distribution of all military sites according to landforms in Chalcolithic (a), EB I-III (b), EB IV-LB (c) and IA (d).

The large economic centers emerge periodically in the Hasa (Figure 43). Their presence can be tied to autochthon development of social complexity as a result of increasing population and growing social and economic differences in the EB I-III or the increasing outside influence of the Moab on the Karak plateau over the Hasa and peripheralization of the region in the IA. The differences in the nature of emergent social complexity are evident in the density of large economic sites in these two periods (see the discussion on the scale-free networks in the next chapter). In terms of their landform preferences, regardless of the temporal associations, sites commonly prefer valleys and ridges. Saddles seem to have less significance in the earlier period. By the IA, as a result of changing political landscape, extensive economic organization and growing importance of trade, the Hasa villages increase in number while maintaining landform preferences.



Figure 43. The distribution of all large economic sites in the EB I-III (a) and IA (b).

The Peaks through 'r.prominence':



Figure 44. 'r.prominence' map of the Hasa drainage at 0.5 km radius (10 meter resolution. The black arrows show the prominent locations in the area). The legend for figures 44 and 45 is indicating the elevation range in meters above the sea level.



Figure 45. The detail of the Figure 44; zoomed into the west Hasa, around As-Safi. The black arrows are pointing to the peaks.

Using another GRASS module, 'r.prominence', the window of analysis can be specifically adjusted to identify the prominent locations on the landscape, as explained in the previous chapter. Figures 44 and 45 show the resultant maps from this module. The images confirm that ridges are common but true peaks are rare in the Hasa (Table 10). Since the landscape becomes flatter at the eastern end (i.e., upper Hasa), peaks are more common in the lower Hasa, especially around As-Safi, which is highly dissected. Figure 45 is a close up of Figure 44 and the black arrows show the peaks in the As-Safi. The settlement patterns, especially the military sites and their distribution, in relation to these peaks will be discussed later in this chapter.

Temporal Site Density:

| Period | Number and Percentage of Sites | Calculated Total Settlement Area (sq km) | Site Density (site/sq km) | Percentage of Hasa occupied | Number of Sites per Century |
|----------|---|---|------------------------------------|-----------------------------------|--------------------------------------|
| Chalco. | 37 / 11.04 | 0.0463 | 0.0380 | 4.77 | 0.0411 |
| EB I-III | 88 / 26.27 | 0.1147 | 0.0905 | 11.81 | 0.08 |
| EB IV-LB | 24 / 7.16 | 0.4840 | 0.0246 | 4.98 | 0.02 |
| IA | 186 / 55.52 | 0.4352 | 0.1913 | 44.78 | 0.465 |

Table 13. The changes in settlement density and the percentage of the Hasa under human activity during the early metal ages.



Figure 46. The bar chart showing the length of each time period and the changes in number of sites throughout the periods. The change in the settlement activity from the EB I-III to the EB IV-LB is striking especially since both periods are similar in duration. The shortest period, IA, witnesses the densest occupation.

Based on the data presented in Table 13, the following observations can be made about the emergent patterns in relation with temporal changes in site density. Firstly, the increase in the settlement density from the Chalcolithic to the EB I-III is gradual and considering the length of time periods, the increase in the number of sites is a local (i.e., without external influence, autochthon) development. Given the wetter and warmer climatic conditions (Figure 56), this is an expected development of the settlement systems. Secondly, the drop in site density from the EB I-III to the EB IV-LB is striking and it reveals the scale of abandonment in the drainage. This group covers three different time periods, it lasts equally long with the EB I-III and the unit scaling of the settlement data from this period clearly reveals the abandonment of the Hasa for a long period of time. The possible reasons of this abandonment and their socio-economic implications have been discussed in this chapter and are examined further in the following chapter. Finally, the IA witnesses the heaviest settlement activity during the early metal ages. Combined with the evidence that the climatic aridity would still be challenging human socio ecosystems in this period (Figure 56) and the increase in population could not have been maintained without outside contact, it is evident from the settlement systems that the Hasa becomes a periphery of the Moabite state in the north during this period. The social, economic and political reasons of this event are discussed further in the next chapter.

Hasa Watersheds:



Figure 47. The Hasa Basin. The map is prepared by using 'r.watershed' module and contains 662.800 cells draining into a single watershed.

The GRASS module 'r.watershed' is used to prepare the map shown in Figure 47, which identifies the watersheds in a landscape according to the criteria outlined in detail in the previous chapter. The Hasa Basin map (Figure 47) shows the geographical extent of the main watershed in the Hasa. This is the map used in MEDLAND script developed in GRASS for calculating and visualizing the landscape evolution, which is discussed in detail in the next chapter. All of the sites in my research are located within the main Hasa watershed.

Using the same GRASS module, smaller watersheds can be identified. Figure 48 shows the map of fifteen separate watersheds in the Hasa. Each watershed consists of 250.000 cells that drain into a well-defined, proprietary zone, which is defined as a 'watershed'. When a stream network map and the map of sites are overlaid, the

distribution of the early metal age Hasa sites can be better visualized in relation with the naturally defined drainages. A distribution chart of the number of sites in each watershed is given in Figure 49.



Figure 48. The individual watersheds in the Hasa with sites used in this research. Each colored zone consists of 250.000 cells draining into it. The numbering goes from upper left to right and each watershed is assigned an even number. There are fifteen watersheds, from number 2 through 30.



Figure 49. The number and percentage of sites in watersheds, shown in Figure 48. Seven sites in the eastern terminus of the Hasa remain outside the watersheds and therefore are assigned category values of zero.



Figure 50. The most heavily settled watersheds in the Hasa are number 18 (the easternmost basin, 97 sites), number 22 (the central basin, 27 sites) and number 4 (the westernmost basin, 25 sites).

Based on the results of the watershed analysis in GRASS, the three watersheds that have highest number of sites are identified (Figure 50). Although the central ones show dense settlement patterns, the most frequented watershed in the Hasa is located at the eastern terminus of the drainage (Watershed 18). The details on the settlement characteristics are provided in Figure 51.





Watershed 18 has been popular throughout the early metal ages in the Hasa. Following a gradual increase in settlement from the Chalcolithic to the EB I-III, the Watershed suffers from the abandonment at the same scale with the rest of the Hasa. The exponential and sudden increase in site numbers during the IA is observable in the settlement patterns of this basin. The settlement diversity remains high although the great majority of sites are of small economic nature. This points to the fact that the inhabitants of the Watershed 18 sites are mostly engaged in direct production of foodstuff. The low significance of large economic and military sites is important. This suggests that military sites possibly focus on protecting trade routes, villages as more valuable economic investments and this aspect of the military sites is discussed in the following chapter. The elevation range of sites in the Watershed 18 reflects the overall pattern, which is clustered between 700-1,000 masl. The sites also follow the general trends in terms of low internal complexity and occupying valleys and ridges more frequently than other landforms. The dense settlement in the Watershed 18 is an unexpected result given the desert-like nature of its environment however, this supports the hypothesis about the predominantly pastoralist aspect of the demography for the early metal ages.



Figure 52. The ANOVA chart showing temporal changes in the rates of water accumulation. The y-axis is in log-scale and the line connects the mean values of periods. The result does not suggest a significant change throughout the early metal ages (p= 0.8612).

GRASS calculates water accumulation rates (i.e., the number of cells draining into a point or a site in 'r.watershed' module) and the values represent the number of cells draining into a site at a given period. Since there are big differences in range of water accumulation among periods, I used log-scale for the y-axis of the ANOVA chart. The

temporal analyses of water accumulation suggest that the Hasa sites rarely have high values during the early metal ages. Based on the median values of the number of cells draining at a site, the rates from Chalcolithic (7 cells) to the EB I-III (8 cells) do not change much. The coefficient of variation (CV) is a better indicator of the variation across space as a normalized measure (i.e., the standard deviation is divided by the mean) of the distribution. The CV value for EB I-III (9.34) is much higher than the Chalcolithic (1.89), which suggests that there is much greater among the EB I-III sites. The EB IV-LB water accumulation rates (13 cells) suggest an increase in water accumulation rates and this can be the result of 'fine-tuning the elevation of sites' strategy of this period. The low CV value (1.72) in this period indicates greater uniformity in the data. The IA rates drop significantly (9 cells) when compared to the previous period. The CV value is 2.44 and suggests a little variation among the sites. These changes clearly show the gradual drying up trend in climate. More importantly however, the periods of highest settlement density and increased human activity showed low water accumulation values. This indicates that the economic organization in both periods relied on diverse resources and economic activities, such as agro-pastoralism and possibly trade. The ANOVA on the water accumulation rates by terrain types suggests no significant change.



Figure 53. The ANOVA chart showing temporal changes in the distance of sites to water sources. The line connects the mean distance values from different periods. The result does not suggest a significant change from one period to the other (p= 0.0813).

The temporal changes in the proximity of sites to water sources provide additional details about temporal changes in settlement systems. The Chalcolithic sites have the mean distance of 441 meters to the nearest water source, which is farther than expected but considering the fact that sites in this period are mostly on the plateau, this result

should not be surprising. The EB I-III sites get closer to water sources; the mean distance is 302 meters. This implies greater dependence on water as agricultural activities increased in the Hasa. The sites move farther from water sources in the period of abandonment; the mean distance is 482 meters. This suggests lower significance of agriculture for settlements of this period. Complementary economic activities such as pastoralism must have been a more important source of living. The mean distance to water sources is 335 meters in the IA, which is a closer figure to the EB I-III period and represents return to that period's economic organization.

The water accumulation rates do not show great fluctuations through time. The persistent pattern emerging here is the continuously low rates of water accumulation at Hasa sites. This can be a partial result of the aridification and at certain times the inhabitants deal with this problem by moving across different elevation bands. However, the role of subsistence system is also important. Low sediment accumulation rates for millennia suggest that Hasa initially lacks significant environmental resources to support intensive agriculturalist systems. Temporal changes in proximity to water resources fortify the expectations about how inhabitants adjust their settlement systems in order to cope with environmental changes that threaten their survival.

Tracking Environmental Change through Precipitation and Temperature in the Hasa Drainage

Temporal Changes in Precipitation: The weather stations around the Hasa (Figure 54) are used to estimate certain climatic parameters such as temperature and precipitation. Following the discussion about the Macrophysical Climate Modeling (MCM hereafter) presented in the Methodology chapter, the MEDLAND Project prepared the climate models, which produce estimates of critical climatic variables including precipitation and temperature. These are then translated into raster maps for integration with GIS in order to collect and analyze data both regionally and locally. These maps are sometimes referred to as "precipitation landscapes" (Figure 55) since they are like DEMs but instead of showing changes in elevation, they display the variations in precipitation (in mm) across space. The climate models prepared for the southern Levant go as far back as 40,000 BP, at 100-year resolution. Using GRASS, I collected precipitation and temperature (in Celsius) data for each site for the number of centuries a particular period lasted. Then, I averaged these values for the entire time period to represent the precipitation and temperature estimates of that particular phase. A similar approach is followed to illustrate the precipitation changes at weather stations (Figure 56).



Figure 54. The map of the weather stations around the Hasa, which are used for the Macrophysical Climate Modeling. The base map is the precipitation landscape of the southern Levant for 1,000 BP and the location of the Hasa is shown by a shaded relief map.



Figure 55. The precipitation landscape map of the southern Jordan for 1,000 BP, including the Hasa (shown as 50-meter contour map) and the early metal age sites. The legend shows precipitation in milimeters. The differences in precipitation from north to south and west to east are clearly visible in the map.



Figure 56. The weather stations around the Hasa and the average precipitation values (milimeters) from the early metal ages. The weather stations were used for the Macrophysical Climate Modeling.

The estimates from the weather stations clearly reveal the magnitude of aridity in the area during the early metal ages. Two important points emerge from Figure 56. Firstly, the spatial variation in precipitation is significant around the Hasa. Ghor station shows the lowest values, which is in As-Safi. The other weather stations are outside the drainage but surround it and show relatively close values to each other. Secondly, the precipitation persistently drops from the Chalcolithic onwards. Based on these estimates, Chalcolithic is the wettest period in the region. The slight drop in EB I-III does not seem to interrupt increase in settlements. Although desiccation continues in the EB IV-LB, the IA is the period when aridity peaks. It is important to note that this is the period when settlement systems reach their peak density.

Based on these results, it is clear that the climatic changes are not solely responsible for the EB IV-LB abandonment. Additionally, the reasons for sudden and substantial increase in settlement density need to be explained during the IA, given the climatic deterioration evident in the record. Social, economic and political factors, which are addressed in the following chapter, are key aspects of long-terms changes in settlement systems of the Hasa.



Figure 57. The distribution of average precipitation values in the Chalcolithic, EB I-III, EB IV-LB and IA. The count axis shows the number of sites in each bin.

| Period | Mean Precipitation (mm) | Median Precipitation (mm) | CV |
|--------------|-------------------------|---------------------------|------|
| Chalcolithic | 152.103 | 164.107 | 0.52 |
| EB I-III | 245.678 | 219.841 | 0.47 |
| EB IV-LB | 236.463 | 177.208 | 0.46 |
| IA | 155.383 | 136.597 | 0.60 |

Table 14. The summary table showing mean, median and CV values for precipitation from the Chalcolithic to the Iron Age. The values are calculated using the avergaed precipitation values at sites from these periods.

The temporal changes in average precipitation suggests a moister phase in EB I-III than the Chalcolithic based on the observations at sites from these periods (Figure 57 and Table 14). The mean precipitation for the EB IV-LB period is higher than expected because this period was predicted to illustrate a drying trend in the environment. Although the CV value for the EB IV-LB is the lowest among the four periods, the result should be interpreted cautiously because of smaller sample size. The regional climatic data suggest general aridity for the region during this period. The IA mean precipitation value is significantly below the EB I-III and based on the CV value, which is the highest of the four, its interpretation must also be cautious. The higher CV value for the IA can be attributed to the multi-modality in the elevation distribution of sites (Figure 70).

The general trend in the precipitation data suggests that climatic amelioration (i.e., moister) from the Chalcolithic to the EB I-III is followed by regional aridity after the late EB and dry conditions persist during the IA. Under these conditions, the emergence of extensive settlement systems and economic organisation during the EB I-III could have been a factor of moister conditions (i.e., climatically favorable phase). However, during the IA, which is the most arid phase, the reappearance of an extensive settlement system at a much larger scale (i.e., in terms of population dynamics, complex social organization as indicated by villages) is only possible through external influence, which is addressed in the next chapter.



Figure 58. The distribution of average temperature values (Celsius) in the Chalcolithic, EB I-III, EB IV-LB and IA. The count axis shows the number of sites in each bin.

The mean temperature value almost remains constant from the Chalcolithic to the Iron Age (Figure 58 and Table 15). The distribution suggests that sites generally remain in 18-19 degrees Celsius range. The most significant difference between the temperature and precipitation observations from the Hasa is that unlike continuously dropping precipitation from the late Early Bronze Age onwards, temperature does not change. This indicates drying up trends in the region, which gets more severe during the Iron Age.

| Period | Mean Temperature (C) | Median Temperature (C) | CV |
|--------------|----------------------|------------------------|------|
| | | | |
| Chalcolithic | 18.233 | 18.535 | 0.17 |
| EB I-III | 18.319 | 18.265 | 0.13 |
| EB IV-LB | 19.217 | 18.614 | 0.10 |
| IA | 18.248 | 18.099 | 0.05 |

Table 15. The summary table showing mean, median and CV values for temperature from the Chalcolithic to the Iron Age. The values are calculated using the avergaed temperature values at sites from these periods.

Average Precipitation and Temperature by Site Types:

The aim of this section is to explore possible differences among site types on the basis of precipitation or temperature values recorded at sites. Using ANOVA, site types recorded at the Hasa are plotted against estimated values of these parameters through time periods. If the results of ANOVA suggest non-randmness (i.e., p value equals to or smaller than 0.05), then it is possible to suggest that certain types of sites are located at places that receive certain amount of precipitation or meet specific temperature requirements. Otherwise, no association can be made between location of site types and such environmental variables at these places.


Figure 59. The ANOVA chart for EB I-III precipitation variation according to site categories. The line connects mean precipitation values. Although small economic and activity-facility sites show greater range, the result does not indicate a significant change in precipitation according to site types (p= 0.1131).

The Chalcolithic and EB I-III site types do not show significant differences on the basis of average precipitation. As an example, Figure 59 shows the ANOVA chart for the EB I-III. The change in mean values of precipitation according to site types is rejected due to a large (p) value. The EB IV-LB sites have much less variation in rainfall and the sites have close precipitation values (Figure 60), which suggests strategic selection of site locales in this period, when aridity is a major problem for the southern Levant.



Figure 60. The ANOVA chart for EB IV-LB precipitation variation according to site categories. The line connects mean precipitation values. The result does not indicate a significant change in precipitation according to site types (p=0.4132). However, the range of precipitation values for each site type is much narrower in comparison with the site types from Figure 59, suggesting strategic selection of site locales in EB IV-LB.



Figure 61. The ANOVA chart for IA precipitation variation according to site categories. The line connects mean precipitation values. The result suggests a significant change in precipitation according to site types (p= 0.0001). This variation is apparent between the large economic sites (i.e., villages) and small economic sites.

The patterns of IA sites (Figure 61) are slightly different from the previous periods. The large economic sites show higher precipitation averages than the rest of the site types. This suggests that the IA villages are located at places with better rainfall in the Hasa landscape, which are the plateaus to the south of the drainage (Figure 17).



Figure 62. The ANOVA chart for EB I-III temperature variation according to site categories. The line connects mean temperature values. The result does not indicate a significant change in temperature according to site types (p=0.9240).

The results of ANOVA do not suggest that site types in a period varied significantly according to temperature. In Figures 62 and 63, the site types show great overlaps in mean temperature values. These overlaps, which are typical for most data categories in the early metal age settlements of the Hasa, make differentiations on the basis of environmnental variables such as temperature or precipitation difficult and inconlcusive.



Figure 63. The ANOVA chart for IA temperature variation according to site categories. The line connects mean temperature values. The result does not indicate a significant change in temperature according to site types (p=0.0782). However, the wide range in small and large economic sites in this period is noticeable in comparison with Figure 62.

Average Precipitation, Temperature and Site Complexity:

More complex sites (i.e., a site that has six or more features) emerge during the EB I-III and IA periods. The aim of this section is to explore possible relationships between environmental parameters and site complexity (i.e., whether more precipitation or certain range of temperature contributes to higher internal complexity). Based on the ANOVA results however, there is no meaningful pattern or association between the mean annual temperature or precipitation of the localities where sites are located and their level of internal complexity (i.e., the calculated number of features). This lack of general

association between climatic paremeters and site complexity can partly be the result of wide range of precipitation values for low complexity sites (i.e., fewer than three features) (Figure 64), which creates significant overlaps with observations that have higher number of features. The increasing complexity can then, be explained in terms of social and political factors such as the emergence of economic maximization. The only exception to this statement is the Chalcolithic relationship between avergae temperature and the calculated number of features (Figure 65) where sites with more features are usually located below 19 degrees Celsius.



Figure 64. The ANOVA chart for EB I-III precipitation variation according to internal complexity of sites. The line connects mean precipitation values. The result does not suggest significant change in the level of site complexity based on precipitation (p=0.6387).



Figure 65. The ANOVA chart for Chalcolithic temperature variation according to internal complexity of sites. The line connects mean temperature values. The result suggests significant change in the level of site complexity based on temperature (p= 0.0126).

The results of analyses indicate annual average temperature is not a factor in site complexity. Although the most complex Chalcolithic sites show slight prefrence towards lower temperature ranges, this pattern is not robust and was not repeated in other periods.

Average Precipitation and Temperature by Landform Categories:

This section explores any possible relationship between landforms and environmental variables. Using ANOVA, the precipitation and temperature ranges of each landform is tested whether certain landforms are more favorable in terms of such environmental parameters. The terrain types do not indicate major changes according to average precipitation values in the early metal ages of the Hasa. There is great overlap between terrain types in terms of the average precipitation ranges they have and this makes results of ANOVA inconclusive.



Figure 66. The ANOVA chart for EB I-III precipitation variation according to landforms. The line connects mean precipitation values. The result does not suggest association between precipitation and landforms (p=0.6470).



Figure 67. The ANOVA chart for EB IV-LB precipitation variation according to landforms. The line connects mean precipitation values. The result does not suggest association between precipitation and landforms (p= 0.0988).



Figure 68. The ANOVA chart for IA precipitation variation according to landforms. The line connects mean precipitation values. The result does not indicate change in precipitation according to landforms (p=0.1155).

Precipitation and temperature are crucial variables that may have direct and indirect impacts on the settlement systems and subsistence patterns. However, the tests concerning whether variations in these variables contribute to the decision making processes in terms of choosing landforms, locating certain types of sites at locales that receive higher precipitation, or whether the level of site complexity is associated with such climatic parameters return negative results. The common patterns in the Hasa settlement data are significant overlaps (i.e., in landforms preferences, site types and the number of features) with these variables through time and space (Figures 59, 62 and 68). Consequently, the direct influence of climatic variables, such as precipitation and temperature, is not evident in the data set. Such significant overlaps however, can also be informative. Although these overlaps cover wider ranges in EB I-III and IA (e.g., the smal economic sites in Figures 59 and 61, 62 and 63), for the abandonment phase, the range of precipitation values for site types in Figure 60 is significantly narrower. Although this pattern may be partially a result of small sample size, these variations in the spread of data points suggest selective occupation of locales across the landscape in order to take full advantage of precipitation under progressive aridification.

The temporal patterns that emerge from ANOVA results suggest that the inhabitants do not pick site locations primarily on the basis of terrain type (Figures 66-68). Considering the significance of precipitation for habitation, especially in dry lands, elevation, then is the most significant factor in choosing site location. The following section focuses on how settlement systame change in relation to elevation.

Site Distribution Characteristics

General Elevation Distribution:

The previous section focused on precipitation and temperature variables in an attempt to explore possible relationships between these factors and the settlement types, landforms, complexity. The results of these analyses do not suggest clear patterns with few exceptions about the IA (Figure 59) and Chalcolithic (Figure 62). In this section, elevation is taken as the last environmental variable and its possible impact on selecting site locations, land use and social organization are evaluated.



| Mean | 839.76716 |
|----------------|-----------|
| Std Dev | 185.85053 |
| Std Err Mean | 10.154099 |
| Upper 95% Mean | 859.74121 |
| Lower 95% Mean | 819.79312 |
| Ν | 335 |
| Skewness | -0.522447 |

Figure 69. The histogram and the statistics table for the elevation distribution of all Hasa sites.



Figure 70. The ANOVA chart of the elevation of sites by time period in the Hasa. The line connects mean elevation values. The result suggests significant periodic variation in the elevation preferences of sites (p=0.0052). The histogram shows differences in the variance. The EB IV-LB distribution is bi-modal whereas the IA distribution shows multi-modality.

The distribution (Figure 70) shows a clustering of sites between 700 and 900 masl. Although smaller in size, a second cluster can be identified between 1,000 and 1,200 masl. There is considerably low settlement activity below 700 masl. The ANOVA box plots reveal important characteristics of the Hasa sites in terms of their elevation distribution. The box plot for the Chalcolithic indicates a notably narrow distribution of sites within 800 and 900 masl with few extreme observations in the data set. During the EB I-III period this pattern changes; although half of the sites remain within 750 and 900 masl, the spread is much wider. This pattern becomes much more emphasized during the EB IV-LB period. Although the sample size from this period is much smaller -and therefore the results require cautious interpretation- nevertheless the spread of sites is noteworthy across elevation ranges. Additionally, for the first time, multi-modality is

evident in the distribution. The first peak in the histogram is between 800 and 900 masl (32% of sites). The second peak is observed between 600 and 700 masl (13% of sites). The third peak is within 300-400 masl (21% of sites). The spread-out pattern continues in the IA but it gets narrower; 59% of sites remain within 700-900 masl. Moreover, the histogram indicates a major change in the multi-modality from the previous period. The second peak of settlement activity moves to highlands, 1,000-1,200 masl (31% of sites). The low elevation sites (below 600 masl) of the IA create a long tail in the distribution. These sites (n=16) have roughly the same frequency with the low elevation EB I-III sites (n=11).

These characteristics of the settlement data suggest that the land between 700 and 1000 masl is especially valuable for the inhabitants of the Hasa throughout the early metal ages. Starting from the late Early Bronze, depending on the climatic and environmental changes (i.e., changes in precipitation as discussed in the previous section), shifts in socio-political organization (i.e., security, increased regional contacts via trade networks, peripheralization), the settlements start to occupy various parts of the landscape. These characteristics can be summarized in a table.

| Water Accum.* (# of cells) draining/ste) | 7 cells CV= 1.89 | 9 cells CV= 9.34 | 12 cells CV= 2.64 | 13 cells CV= 0.44 | 13 cells CV= 2.1 | 6 cells CV= 2.84 | 12 cells CV= 1.65 |
|--|----------------------|---------------------|---|-----------------------------|----------------------------|--------------------------------------|----------------------|
| Slope Category Number | 1, 2 | 1, 2 | 3, 2 | 2 | 1, 2 | 1 | 1, 2 |
| Dist. to Water * (meters) | 369 | 243 | 652 | 507 | 91 | 393 | 257 |
| Numb of Feature* (CV) | 2 (0.93) | 1 (1.34) | 1 (0) | 1 (0.43) | 1 (1) | 1 (1.13) | 1 (1.27) |
| Precip* (mm.) | 154 | 205 | 296 | 187 | 154 | 315 | <i>L</i> 6 |
| Principal Site Types (Secondary) | SmEc, A-F, Mltr | SmEc (A-F, Vllg) | SmEc –West terminus and valleys– | SmEc – West terminus– | SmEc, A-F – Lower Hasa– | Vllg (SmEc, Mltr) –Lower Hasa– | SmEc (A-F, Vllg) |
| Elev. (masl) | 700- 1,000 | 700- 1,000 | 900- 1,000 | 600- 700 | 300- 400 | 1,000- 1,200 | 006 -002 |
| Period (n), <i>mode of</i> <i>elevation</i> | Chalcolithic (32) | EB I-III (59) | EB IV-LB (7) i | EB IV-LB (3) ii | EB IV-LB (5) iii | IA (38) i | IA (109) <i>ii</i> |

Table 16. The summary table showing environmental variables, predominant site types and complexity patterns according to periods and modes in elevation. (*) denotes median values as a precaution to the effects of outliers.

The analysis of general elevation distribution of the Hasa sites reveal significant details about land use patterns during the early metal ages. Based on the information provided in Table 16, the patterns can be grouped into two in analyzing the spatiotemporal evolution of the Hasa settlement systems: the critical environmental variables such as slope, precipitation, water accumulation rates and the socio-economic and political factors such as the principal site types and complexity level of settlements. The basis of the following discussion is the temporal differences in elevation of sites (Figure 70 and Table 16). The earlier sites (i.e., Chalcolithic and EB I-III) show preference for 700-1,000 masl. Starting with the EB IV-LB period, the distribution of sites becomes multi-modal: the BA sites are either below or above the widely popular 700-900 masl. The IA sites not only use this popular range but also settle on highlands between 1,000 and 1,200 masl (Figure 70). Such changes in modes of elevation support the statement about the extensive nature of land use and economic organization throughout the later phases of the early metal ages. Combined with the precipitation and landform data (discussed below), these changes in elevation show that pastoralism gains economic significance and tribes practice vertical transhumance in the BA. The vertical expansion of settlements continues in the IA due to the peripheralization of the Hasa (see the related section in the next chapter). Such vertical expansion of settlement patterns contrast with the earlier –Chalcolithic and EB– sites where elevation distribution is in a limited range. The EB increase in settlement density remains within that range, hence suggesting a horizontal expansion of settlements on the landscape.

The environmental variables (i.e., precipitation, steepness of terrain (i.e., slope characteristics), distance to water source, and water accumulation rates), which vary according to elevation, are also summarized in Table 16. The median precipitation values show significant increase (of 51 mm) from the Chalcolithic to the EB III in 700-1,000 masl range. After EB III however, the sites have to occupy higher grounds (hence, the multi-modality in Figure 70) in order to receive sufficient rainfall. The median precipitation values for 700-1,000 masl range are 205 mm for the EB I-III and 109 mm for the IA (Table 14). The deficiency is 96 mm. These results suggest that with the onset of the aridity in late EB, the inhabitants fine-tune the elevation in order to ensure sufficient rainfall. The exponential increase in settlement density under such arid conditions suggests a major change in political and economic organization in the Hasa (see the section on the peripheralization of the Hasa in the next chapter). The slope variable suggests that inhabitants almost always prefer flatland (i.e., 0-9 degrees of slope). Except for highland settlements during the EB IV-LB, medium slope (>29 degrees) or steeper lands are not settled. The preference for steeper slopes in the EB IV-LB however, supports the pastoralist nature of economic organization –since slope is not a factor in goat herding- and selecting steeper surfaces is expected given that the settlements frequent the highly dissected western terminus in this period.

In terms of distance of sites to water sources, the EB I-III sites show a trend of being closer to water sources: the difference from the Chalcolithic is 126 meters. As a result of increasingly arid conditions of the BA and IA, the later sites show differential patterns in this respect (Figure 53). The highland sites are significantly far from water sources (652 meters) where as lowland occupants preferred to be very close (91 meters) during these periods. The lowland sites are small economic and activity-facility sites, which need easier access to water. On the other hand, the highland sites, especially of the IA, are villages, which cannot survive without reliable rainfall and therefore have to occupy plateaus. The water accumulation rates (Figure 52) remain very low during the Chalcolithic and EB I-III, although the latter has the highest CV, which suggests that there is much greater variation in this group of observations. The accumulation rates increase during the EB IV-LB, as the settlements occupy lower lands and CV values are not extremely large. This can be attributed to the general attempt of locating sites near streams, which have already started down cutting. The IA water accumulation rates remain close to Chalcolithic and EB I-III periods. Considering the fact that this is the most arid of the four periods and it has the densest settlement activity, it is possible to suggest that agricultural production is not the sole livelihood of settlements in the Hasa (see the section on the trade routes in the following chapter). In fact, it is highly likely that Hasa subsistence becomes largely dependent on sedentary pastoralist while villages act as socio-political and economic (i.e., market) centers.

The socio-economic factors summarized in Table 16 can be grouped under types of sites and site complexity level. In terms of site types, the composition shows a combination of small economic, activity-facility and military sites in the Chalcolithic. This gradually changes and the small economic sites come to dominate the distribution starting with the EB I-III (compare Figure 9 and 10). The only exception to this is the IA villages in the highlands (i.e., 1,000-1,200 masl). With few BA exceptions shown on Table 16, the sites almost always follow the general trends of their period in terms of terrain preferences (Figures 31, 40-43 and Table 12) and sections of the drainage (i.e., choosing between valleys and ridges, remaining in the western terminus or spreading towards the northern plateau). The site complexity starts out to be high and shows consistent decrease throughout the BA (Table 16). Such drop in the later phases of the BA support the argument of pastoralism becoming a more significant mode of subsistence. With the IA, internal complexity of sites in these ranges slightly increases. Although the population and site density increases during these periods, the inhabitants never attempt to maximize economic returns through intensive land use (i.e., selectively using certain terrains for specific activities). These patterns support my hypothesis that during EB I-III and IA the economic organization focuses on extensive land use (Figures 11-12 and 33 -37).

The results of statistical tests on the critical environmental (i.e., precipitation and temperature) and landscape data (i.e., slope, landform, watershed composition, water accumulation and distance to water sources) in order to explore possible relationships among these variables and the settlement systems of the Hasa (i.e., site type diversity, internal complexity, site size and density). The outcomes of these tests mainly point out that the Hasa experiences continues and progressive aridity in the early metal ages, which becomes more severe in the IA (Figure 56-57). However, based on both temporal site density calculations and several ANOVA tests, neither precipitation nor temperature seems to be a contributing factor in the evolution of the Hasa settlement systems, with the exception of the IA (Figure 61). The most decisive factor in the change of settlement

systems from one period to the other is elevation in the Hasa (Figure 70 and Table 16). The earlier period sites (i.e., Chalcolithic and EB I-III) show utilization of wide variety of landforms within a narrow elevation range. Combined with other settlement data (i.e., site complexity and diversity), the EB I-III period represents the emergence of the extensive economic organization for the first time in the area, possibly as a result of gradual and local development (Figures 10, 22-23, 40-43). These patterns change with the EB IV (ca. 2300 BC), as the Hasa starts experiencing major depopulation and abandonment. Both EB IV-LB and IA settlements show multi-modality in terms of their distribution. The reduced site complexity and diversity (i.e., of site types and landforms utilized) suggest increasing significance of transhumant pastoralism in the Hasa hence leaving a pattern of vertical movement in the Hasa landscape. The sudden and exponential increase of site density during the IA (Figure 6), which is the shortest of all the archaeological periods dealt with in this research, implies that the socio-political conditions in the region change during the IA (Figure 12, 21-24, 40-43).

The following chapter focuses on how the inhabitants of the Hasa respond and adjust to such climatic changes, how they adjust social organization, what additional activities emerge through time to support tribal groups economically, how social complexity changes from one period to the other and finally how agropastoralist activities of the Hasa population may have affected the Hasa landscape in the long term.

Chapter 6

SOCIAL FACTORS OF CHANGE AND HUMAN RESPONSES

Introduction

The aim of this chapter is to evaluate changes in the environment and settlement patterns of the early metal ages in the Hasa in a social context. The presentation of the results in this chapter is centered on the research questions that are concerned with cooperation and conflict (i.e., social fission and fusion), whether trade and exchange might have become significant economically in the Hasa from time to time and how the social organization changes at temporal scale following the shifts in settlement systems, changes in population density and types of economic organization in the region (hierarchy vs. heterarchy). These aspects have been discussed in the Methodology chapter.

Cooperation and Conflict throughout the Early Metal Ages in the Hasa

A detailed picture on the changing social dynamics of the Hasa population from cooperation to competition has been provided in the Methodology chapter. The focus of this section is the presentation of results of the GIS and statistical analyses of military sites, since their presence, composition and density during each period are expected to illustrate how (i.e., cooperation and competition) and in which direction (i.e., social fission or fusion) these dynamics change. The thematic map (Figure 71) shows the distribution of forts and towers. Although the distribution differences maybe a function of sample size, two major points emerge from this map. Firstly, towers dominate the composition of military sites during the early metal ages in the Hasa. Towers cover the southern plateau and the eastern desert. Secondly, forts reveal a much more limited but specific distribution. They are denser in the select drainages of the eastern Hasa with a single exception in the southern plateau.



Figure 71. The thematic map of the military sites in the Hasa in relation with the stream network in the drainage. Forts are represented by yellow dots while cyan dots denote towers.

The distribution patterns can be better evaluated and contextualized in terms of temporal change by looking at changes in military site density through time and how these changes compare with the overall settlement density patterns in the Hasa. The results of such comparison provide valuable insights about how much the military sites are significant in each period and hence what the social cohesion is like.



Temporal Distribution of Military Sites and Site Density:

Figure 72. The stacked bar chart for towers and forts from each period (y-axis). The x-axis shows the counts of sites.

| Period | Number and Percentage of Sites | Total Military Site Area (sq Km) | Site Density (site/sq Km) |
|--------------|--------------------------------------|--|---------------------------------|
| Chalaalithia | 7 / 19 | 0.0019 | 0.0072 |
| Charcontine | | | |
| EB I-III | 7 / 8 | 0.0051 | 0.0072 |
| EB IV-LB | 1 / 4 | 0.0001 | 0.0010 |
| IA | 20 / 11 | 0.0186 | 0.0205 |

Table 17. The temporal density of military sites in the Hasa throughout the early metal ages.

The temporal comparison of military site composition and their frequencies (Figure 72) reveal that with the exception of the abandonment phase, the military sites in the Hasa maintain a certain composition: there are more towers than forts. Although this pattern is not surprising for the EB I-III and IA periods due to heavier site density and

other economic activities such as trade in these periods, the high frequency of military sites in the Chalcolithic is surprising. Given the limited geographic extent of the Chalcolithic settlements (Figure 14), such high numbers of military sites suggest the need for protecting the economic investments. This pattern may be contrary to the presumed demographics, low population density of the area and relatively peaceful settlement in the Hasa during the Chalcolithic (Tables 4-5). Two interesting patterns emerge from Table 17. From the Chalcolithic to the EB I-III, the first phase of settlement expansion and the emergence of extensive economic organization, the military site density remains constant. Although the geographic locations of military sites in the latter period change, the number does not change. The major change in EB I-III is the size of military sites, which increases almost three fold. The constant site density but changing locations and increasing size suggest that the "mission" of military sites are better defined in the EB I-III since there are more sites in this period, which are distributed across the Hasa. This means that the organization and distribution of military sites in this period aim to create a network of military sites (i.e., covers larger area with military sites). This aspect of military sites is addressed in the section on the trade routes below (Figures 73 and 77, Table 18). During the abandonment and depopulation period, there is only one military site and it is impossible to evaluate patterns on the basis of a single site. However, this lack of data also shows the scale of abandonment in the area. The IA pattern is interesting because this period represents the return of the extensive economic organization –unlike EB I-III, this time it is through peripheralization (see the related section below)- under sudden and exponential increase of settlement density. The total area covered by military

sites increase significantly. More frequent military sites and larger area covered by them suggest another change in the "mission" of these sites (Figures 73, 79 and Table 18). These changes are also discussed under the trade routes section.

| Period | Site Density | Military Density | Change |
|--------------|--------------|------------------|-----------|
| Chalcolithic | 0.0308 | 0.0072 | Initial |
| EB I-III | 0.0833 | 0.0072 | Unchanged |
| EB IV-LB | 0.0236 | 0.0010 | Declined |
| IA | 0.1707 | 0.0205 | Increased |

Table 18. The comparison table for temporal changes in densities of military and other site types.



Figure 73. The graphical comparison of the data presented in Table 18.

Landform Distribution of Military Sites and Site Density:

The landform preferences of military sites closely follow the overall preferences sites for landforms, which are discussed in the previous chapter (Figure 42). The temporal patterns can be summarized as follows: with the settlement expansion during the EB I-III and IA, the types of landforms utilized by the military sites changes and especially in the latter period the diversity of landforms increase. Consequently, the distribution of military sites suggests a "networked" approach (i.e. covering larger areas of the Hasa) for protecting economic investments, whether these are small economic sites in the EB I-III or villages along with possible trade routes as in the IA. This implies an economic and political organization where tribes cooperate for economic maximization during the EB I-III and IA. The possibility of social conflicts during the abandonment phase in the Hasa is reduced with a highly spread-out settlement pattern whereas Chalcolithic period seems like highly competitive based on high density of sites in a limited area of settlement.

Comparing the towers with forts in terms of their temporal landform preferences does not reveal much information. Forts are rare in general and they are not recorded for the abandonment phase. In all other periods, their landform preferences are parallel with the towers. Consequently, an argument for different landforms for military site types is not possible. Both forts and towers have very limited diversity in landforms occupied, with the exception of the IA towers (Figure 74).



Figure 74. The landform distribution of the IA towers (n=14). The IA towers show the highest diversity of landforms among the Hasa military sites.

| Landform Category (N of sites) | Landform Area (sq Km) | Percentage Cover of Landform | Site Density (site/sq Km) |
|--------------------------------------|-----------------------------|------------------------------------|------------------------------|
| Level Terrain (4) | 249.54 | 25.07 | 0.0160 |
| Valley (9) | 320.74 | 32.22 | 0.0280 |
| Saddles (6) | 79.35 | 7.97 | 0.0756 |
| Ridges (16) | 276.49 | 27.77 | 0.0578 |
| Peaks (0) | 55.09 | 5.53 | 0 |

Table 19. The density of military sites according to landform categories. The colors for landform categories and area information are the same with Table 10.

It is interesting to note from Table 19 that peaks are not utilized and saddles as well as level terrain show some activity since these landforms do not have defensive advantage. The distribution of military sites suggests that the defensive significance of landform is not relevant in locating the sites. Therefore, their distribution needs to be evaluated in relation with other sites (especially villages) and trade routes that have economic significance, as outlined above. The military site density on saddles is the highest partly because the smaller total area of this landform in the Hasa. The valleys and ridges are roughly comparable in terms of their size (i.e., valleys have 16% more area in the Hasa) but military sites are almost doubled on the ridges. This suggests clear preference for ridges, which are rich in site type and temporal diversity as well as showing high internal complexity at few sites (Figure 36). The Hasa military sites do not show significant temporal changes when subjected to ANOVA based on size, precipitation, slope or elevation variables. As an example, in Figure 76 the result of site complexity analysis is provided.





Based on the distribution of the most common site types (i.e., small economic,

activity-facility and large economic sites) on the landscape, their relationships with the military sites can be explored. In order to bring a realistic explanation to the issue of what the functions of military sites have been in the Hasa and how these functions might have

changed from one period to the other, GRASS module of 'r.walk' has been used in preparing Figures 76-79. The procedure has been explained in the Methodology chapter in detail. In short, the maps below (Figures 76-79) show the zones of an hour (i.e., 60 minutes or 3,600 seconds) of walking distance on the landscape, in any direction, from each military site. The comparison of maps suggests interesting changes in how the function of military sites changes through time based on the variations in the coverage of military "networks" and sites included in these one-hour zones periodically. *The Chalcolithic Military Sites in Relation with Villages, Small Economic Sites and*





Figure 76. The map of the Chalcolithic military sites (blue crosses, labeled as towers or forts) in relation to small economic sites (red circles) and activity-facility sites (black triangles). The yellow-green zone denotes the walking distance of one hour (3,600 seconds) from any military site in any direction. The legend shows different gradients of time in seconds.

The Chalcolithic settlements frequent the upper (east) Hasa. This pattern remains unchanged for the remainder of the early metal ages, as it is discussed in the previous chapter (Figure 50-51) and below (especially Figure 79). The relatively dense presence of Chalcolithic military sites almost creates a line of defense with NW-SE axis. The military sites are numerous in the Wadi el Ali in this period and their distribution does not suggest special attention to any particular type of site. Based on the hour-walk patterns (Figure 76), it is visible that the Chalcolithic military sites are able to reach all of the sites, except for two (1 activity-facility and 1 small economic site) –5.4% of sites–. The military sites of this period seem to focus on securing all the settlements.

<u>The Early Bronze Military Sites in Relation with Villages, Small Economic Sites and</u> Activity-Facility Sites:



Figure 77. The map of the EB I-III military sites (blue crosses, labeled as towers or forts) in relation to small economic sites (red circles), activity-facility sites (black triangles) and large economic sites (yellow octagons). The yellow-green zone denotes the walking distance of one hour (3,600 seconds) from any military site in any direction. The legend shows different gradients of time in seconds.

The settlement expansion across the Hasa landscape during this period also represents the beginning of extensive economic organization in the drainage. The higher frequency settlement activity continues in the upper Hasa while a second nucleus of settlement is added to the west-central drainages. Combined with evidence presented so far, this spread provides further support for extensive economic organization. The central drainages remain lightly settled. The one-hour walking distance map (Figure 77) of military sites supports this. Based on this map, there are few military sites in the central and east Hasa. The latter still has the densest small economic site presence in this period. More frequent presence of EB I-III military sites are recorded in the west Hasa, where settlement density remains low mainly due to dissected terrain. The first villages in the Hasa seem to remain close to the southern plateau with few exceptions. These patterns suggest that the military sites may have the function of protecting trade routes, which are more common in the lower Hasa (see the section on the trade routes below and Figure 88), in addition to maintaining security at sites except for 2 activity-facility, 13 small economic and 4 large economic sites are not in the walking distance –making up 21.6% of sites—. The increase in the number of sites that are left outside the walking zones can be a function of extensive economic organization (Figures 10 and 80a), which requires occupation of diverse landforms for taking advantage of wider resources. The low frequency of the military sites in the east Hasa suggests the replacement of the Chalcolithic security concerns (i.e., settlement-oriented organization of the military network) by a new focus in the EB I-III: trade routes in the west Hasa.

Facility Sites:





The EB IV-LB abandonment in the Hasa is clearly visible in Figure 78, which shows the scale of depopulation and loss of site type diversity. The upper Hasa is completely void of occupation, with the exception of two small economic sites. The absence of large economic sites in this period also causes interruption to settlement activity on the southern plateau except for a small economic and an activity-facility site. West Hasa, especially Afra and Thamad drainages show major settlement activity in this period. Considering the dissected landscape of this part of the Hasa, this agrees well with the multi-modality of elevation distribution of sites from this period (Figure 70). Based on Figure 78, the only military site, a tower, is almost centrally located in this relatively densely occupied sector of the Hasa, which also makes coverage of most sites easier within an hour's walk of distance. This walking zone does not cover 2 activity facility and 8 small economic sites (41.6% of sites). The ratio of sites remaining outside the walking zone is significantly higher than the earlier periods. This may partly be the result of relatively low number of EB IV-LB sites recorded in the Hasa. More importantly, this fact supports the earlier discussion that transhumant pastoralism becomes more significant in this period, based on the multi-modality of elevation distribution of sites. Therefore, sites mainly show patchy distribution on the landscape, usually far from a short walk's distance, moving back and forth as part of the pastoralist land use strategies (Figures 11 and 70), which make it difficult to cover all these sites with a single military site (see Figure 81 and related discussion).

The Iron Age Military Sites in Relation with Villages, Small Economic Sites and Activity-





Figure 79. The map of the IA military sites (blue crosses, labeled as towers or forts) in relation to small economic sites (red circles), activity-facility sites (black triangles) and large economic sites (yellow octagons). The yellow-green zone denotes the walking distance of one hour (3,600 seconds) from any military site in any direction. The legend shows different gradients of time in seconds.

The IA represents a major transformations in terms of settlement expansion and increase in density (i.e., the vertical spread of IA sites across the landscape and making use of landforms at different altitudes as opposed to the EB I-III horizontal spread of sites that mostly remain within well-defined elevation range), following a long period of abandonment and revival of habitation in a short period of time (Figure 6). Figure 79 shows that the east Hasa continues to be the major locale of attraction for small economic

sites. There are several clusters of military sites in this area, which are usually towers. Unlike EB I-III (Figure 77), during the IA, the sites show more balanced distribution in the rest of the Hasa (i.e., spread across the landscape instead of zones of activity). The central drainages show slightly more settlement activity with numerous small economic, large economic and military sites. The lower Hasa shows more sporadic distribution of settlements and majority of these sites are small economic sites with several villages and few activity-facility sites. The military sites are more common on the southern plateau than the west Hasa, which can be a function of concurrent increase in the density of large economic sites here. The one-hour walking distance map (Figure 79) shows that the military site network in the IA covers all of the settlements. This change in the coverage of military sites is clearly a function of the re-emergence of extensive economic organization (Figures 12 and 70). More importantly, the increased presence of military sites in the west Hasa (from four EB I-III to nine IA military sites), which are densely located around the large economic sites of the southern plateau, suggest additional functions for the military sites. Given the fact that the IA changes in settlement systems indicate peripheralization of the Hasa (see the related section below), the Hasa may act as a border between Karak and Edom, which requires patrolling of the Hasa more efficiently. Additionally, the rising significance of long-distance trade may require the rearrangement of military sites in order to protect the trade routes more efficiently as well as maintaining security for the sites in the Hasa (see the section on the trade routes below). In short, the military sites of the IA show multi-purposed pattern of distribution. First, they protect economic investments (e.g., activity-facility, small economic sites),
and provide security to villages. Second, the military sites control trade routes connecting the north and the south (Figure 88), via the west Hasa. Third, the military sites act as patrolling stations for the Hasa, which is possibly the border between Karak and Edom states (Figures 81-82).

The Sites that Remain Outside the Walking Zones from the Military Sites:

This section presents a brief overview of the sites, which fall outside the one-hour walking zone of military sites. The aim is to look at some of the critical variables in an attempt to identify common patterns that may suggest why these sites are not covered by the military network of relative periods.





-40 -35 -30 -25 -10 -10

57%

e.

Figure 80. The distribution charts for temporal (a), site type (b), elevation (c), calculated number of features (d) and landform (e) details of sites that are left outside the walking zones from Figures 76-78.

There are more EB I-III sites that remain outside the walking zone of military sites, followed by the sites of abandonment period (Figure 80a), and great majority of these sites are small economic type (Figure 80b). Based on the number of calculated features (Figure 80d), it is clear that these sites are usually simpler (i.e., lower number of features) while covering wide variety of elevation bands (Figure 80c) and landform categories (Figure 80e). These distribution patterns do not suggest a particular factor that is common among all these sites that may be used as a criteria to leave sites out of the

-40 -35 -30 june) -25 05 -10 defensive networks since great majority of the early metal age sites in the Hasa show these patterns. It is possible therefore that the sites (mainly small economic sites) that are left outside the military networks have random aspects and this is not the result of a patterned behavior.

The Peripheralization of the Hasa during the Iron Age

The reasons for the possible peripheralization of the Hasa during the Iron Age under the Moabite state (the most powerful IA state in the region) in the Karak Plateau have been mentioned in the preceding chapters and in the previous section on the military sites. To recapitulate, these are: the Moabite attempt to make the Hasa a periphery in order to maintain security along its southern border with the Edomite state by creating a "buffer zone", taking advantage of the caravan trade that crosses the Hasa at As-Safi (see the section on trade below) and, finally to complement its heavy agricultural subsistence with pastoralist elements of the Hasa -see Andrews and others (2002) for the wide variety of resources on the Karak Plateau-. Considering the marginal environmental and climatic parameters in the drainage, it is clear that Hasa cannot sustain intensive resource extraction (i.e., farming). Consequently, the nature of the Iron Age economic activities remain extensive and a hybrid of pastoralism and agriculture, which is supported by unchanging site complexity (see the section below on comparison of EB I-III and IA villages) but widespread settlement activity on the Hasa landscape, as has been discussed throughout this and the previous chapter. The predicted impacts of such political changes on the Hasa settlement systems can be summarized as the emergence of a significantly denser settlement system, which is geared towards extensive resource procurement by

incorporating landforms and diverse resources at different elevation bands (Figure 70) and on variety of landforms (Figure 12, 17, 33-37, Table 12).



Figure 81. The EB I-III villages (black outlined yellow boxes), military (blue stars), activity-facility (black triangles) and small economic (black outlined red circles) sites. The majority of settlement activity is reserved to the upper Hasa but the west-central drainages show signs of lighter settlement activity with variety of site types. This is the major difference, other than the density of settlement, with the IA settlement system.



Figure 82. The IA villages (black outlined yellow boxes), military (blue stars), activity-facility (black triangles) and small economic (black outlined red circles) sites. The heavy settlement activity on the southern plateau, which is mainly consisted of villages, is striking in this period. It is notable that the small economic and activity-facility sites are denser in the upper Hasa, which creates rather sporadic distribution of such settlements in the lower Hasa, except for the military sites.

In terms of site types (i.e., except for the large economic sites): the Iron Age settlement patterns (Figure 82) unequivocally shows significant increase in site density as well as site type and terrain diversity, when compared with the EB I-III (Figure 81), which is the first phase of significant population increase, dense settlement activity and economic diversification (Figures 10, 12, 40 and Tables 9, 12, 13). The EB I-III expansion, which is autochthon and gradual based on site type diversity and increase in site density, brings rather limited distribution of variety of sites across the landscape. It is also important to consider that sites of this period remain within 700-1,000 masl range while pursuing extensive economic organization (Figure 70 and Table 16).

The Iron Age boost in the settlement activity takes place in such a short period of time when the Hasa is experiencing the most arid phase of the early metal ages (Figures 56, 57, 61 and Table 14). As part of these environmental changes (i.e., the adjustment of subsistence patterns to emphasize pastoralism, following the changes in the environment) and partly due to the peripheralization of the Hasa (i.e., the economic incentives of the mainly pastoralist population in the Hasa to the mainly agriculturalist population of the Karak Plateau), the IA inhabitants settle landforms at different elevation bands (i.e., vertical expansion of settlement) (Figure 70 and Table 16).

Comparing the IA site distribution (Figure 82) with the EB I-III (Figure 81), it is apparent that the IA site type variation is greatly reduced in the west-central portion of the Hasa. The sites here are mainly villages, with some military sites and few small economic and activity-facility sites. In the upper Hasa on the other hand, the composition of settlement changes and it becomes heavily dominated by small economic and activityfacility sites with few military settlements. This creates an almost "divided" use of landscape where especially the southern plateau of the west Hasa is reserved for the villages as opposed to the upper Hasa being settled by sites with focus on direct production of foodstuff. The clustering of villages on the southern plateau also needs to be considered from the aspect of long-distance trade (see below). Based on changes in settlement patterns and given the fact that the reduced population from the EB IV-LB cannot increase so significantly in such a short period (i.e., 400 years, Figure 6), the presence of an external stimulus for IA settlements and source of immigrants, such as the emergence of the territorial states around the Hasa, is likely.

Temporal Changes in Large Economic Sites:

Large economic sites (i.e., villages) emerge periodically in the Hasa, when settlement density increases and the subsistence seems to be based on agro-pastoralism (i.e., increased diversity of site types). The social, economic and political functions of villages have been discussed previously. The comparison of EB I-III and IA villages in terms of size, complexity, landform preferences, elevation and precipitation may shed light on the peripheralization issue of the Hasa.

The site size comparison of the villages (Figure 83) from two periods does not show any significant change in this variable even though villages are more frequent in the IA. The IA histogram of the ANOVA chart is important however, for showing the changes in social complexity. The relatively higher number of smaller villages in comparison to fewer but larger settlements is analyzed later in the chapter, in the context of scale-free networks and social complexity in the section on social complexity.



Figure 83. The ANOVA chart for villages showing the temporal change in site size (p=0.9088). The line connects mean size value of sites in each period. The result does not show significant change in terms of sizes of villages.



Figure 84. The ANOVA chart for villages showing the temporal change in site complexity (p=0.8736). The line connects mean number of features in each period. The result does not show significant change in terms of complexity of villages.

The internal complexity of villages does not show significant variation from the EB I-III to the IA (Figure 84). Although the IA represents a period of major external social, economic and political influence, the complexity at these sites does not increase significantly. However, like Figure 84, the IA histogram in Figure 85 has also important implications for the emergent social complexity in the Hasa at this time.



Figure 85. The landform distribution of EB I-III (a) and IA (b) villages. The IA settlement expansion brings opening up of level terrain to villages as the settlement density on other landforms, except for peaks, increases significantly.

The EB I-III landform distribution of villages (Figure 85a) follow the horizontal extensive economic organization of this period by remaining on certain landforms while the vertical extensive economic organization of the IA (Figure 85b) brings the opening up of level terrains (i.e., such as the southern plateau) as well as the increased settlement density on previously settled landforms by EB I-III villages.



Figure 86. The elevation distribution of EB I-III (a) and IA (b) villages. The EB I-III villages are located within a well-defined elevation range, which is typical for this period's horizontal extensive settlement system. On the other hand, the IA vertical settlement expansion allows spread of villages in various elevation bands. This is evident from the bi-modal distribution in 87b.

The elevation ranges of villages from the EB to the IA shows a major change (Figure 86), which agrees well with the overall results for temporal elevation changes in the Hasa (Figure 70). The IA sites, in general, are known to have occupied widely varying elevation bands and large economic sites are not an exception (i.e., bi-modality in Figure 86b). This is a function of the IA economic extensive organization that takes advantage of the landscape by vertical expansion of settlements, which is not observed in the EB I-III.



Figure 87. The comparison of average precipitation values at EB I-III (a) and IA (b) villages. The EB I-III villages are located within a well-defined elevation range, which is typical for this

The differences in the average precipitation values from the EB I-III to the IA (Figure 87) show highly patterned choices in terms of locating –especially IA– villages on the landscape. Mainly as a result of wetter climatic conditions (Figure 56), majority of the EB I-III villages –72%– receive more precipitation (i.e., 300-500 mm). In the IA, only 37% of villages receive 300-400 mm of rainfall, which is the peak value for this period. This is mainly due to increasing aridity of this period. However, it is important to

consider that the bi-modal elevation distribution and highly diverse landform preferences of this period contribute to better precipitation values for the IA villages and this is supported by the fact that 15 IA villages that have the highest precipitation averages are located on the southern plateau. In short, considering the general drying trend in this period, the IA villages may be taking advantage of parts of the Hasa with higher precipitation when compared to their EB I-III counterparts (Table 20). More importantly however, such spatial separation can point to social (i.e., urban vs. rural), political (e.g., elite vs. peasant/herdsmen) even ethnic differences.

| Period | Median Precipitation for Villages (mm) | Median Precipitation for Other Sites (mm) | Difference |
|----------|--|---|------------|
| EB I-III | 322 | 219 | 103 |
| IA | 268 | 111 | 157 |

Table 20. The summary table comparing median precipitation values for villages and other sites in the EB I-III and IA.



Figure 88. The map of IA villages (black outlined yellow boxes), in relation with military (black stars), and the villages on the Karak Plateau (black filled circles). The red line is the Roman Via Nova. The black lines indicate possible trade routes between the Hasa and the Karak Plateau. The green to red zones are view sheds of the IA military sites. The scale shows how many military sites view a given spot on the landscape.

The significance of long-distance trade has been emphasized several times in the context of the evolution of the IA settlement systems. Such changes also reflect transformations in social organization. The map in Figure 88 shows possible routes of movement between the Hasa villages and the villages on the Karak Plateau –the possible core region of the Hasa peripheral settlements–, calculated and mapped in GRASS GIS, across the Hasa drainage using the methods described in the Methodology chapter. The IA distribution of villages in relation with military sites is evaluated here. Since the overwhelming majority of small economic and activity-facility sites are located in the

upper Hasa, the dense presence of villages on the southern plateau suggest that such significant political and economic settlements deliberately target this sector of the Hasa not only for better environmental conditions (i.e., higher precipitation) but also for its proximity to trade routes that cross the Hasa from the west. The Roman Via Nova (the red line in Figure 88) seems to be a truly later path in date since the number of sites around Via Nova is quite low.

The relationships among the Hasa villages and the Moabite villages on the Karak Plateau in IA is encouraging in terms of reconstructing some of the possible trade routes since none is known to us currently. The 'r.drain' paths in Figure 88 show possible routes of communication between these two groups of sites. The pattern emerging from this analysis is not purely natural. As explained in the Methodology chapter, the user has to specify the origin and destination of movement; the calculations are then based on these points and the landscape characteristics such as slope. Therefore, the map in Figure 89 should not be interpreted as a clear and solid proof of the existence of roads and routes. Rather, the paths on the map are suggestions; if these groups were related, the least cost path of crossing the Hasa in order to get the Karak villages had to take one of these routes. Therefore, the results here are only suggestions. In order to make better estimations of such IA routes between the north and the south, I incorporated other settlement data, especially the military sites. Following the discussion of the "line of sight" analysis described in the Methodology chapter, I prepared view shed maps using each IA military site and combined these view sheds in a single map, which is color coded for the number of overlaps in a specific area if that particular spot on the landscape

is visible from one or more military sites (i.e., green to red zones in Figure 88 and the legend of the figure). Then, it is possible to identify how many military sites cover which possible trade routes. The underlying assumption, as emphasized before, is that as a trade route is visible from more than one military site, its significance -and therefore the possibility of the route being a true path of communication-increases. It is already clear from Figure 79 that the IA military sites are within easy reach of the villages and this is mainly the function of each military site being located at the branching off point of routes. Figure 88 shows a total of five routes -many more if branches are counted- each of which is at least visible by a single military site. If these paths are assumed to be real, the few small economic and activity-facility sites, shown in Figure 89 below, benefit from being close to -or, on the path- of exchange even if the level of site complexity remains low at these sites. A final remark about Figures 88 and 89 is the limited number of possible crossing points on the main Hasa channel. Although there are 29 villages in the Hasa, there are only eight paths identified in 'r.drain' to cross the dissected landscape of the Hasa to reach the southern plateau.



Figure 89. The duplicate of the map in Figure 89 with small economic (black outlined red circles) and activity-facility (black filled triangles) sites shown. These sites dominate the upper Hasa but the few in the west-central Hasa are generally closely located to the possible routes to the north, which are covered by military site view sheds.



Figure 90. The map showing villages (black outlined yellow boxes), military sites (black stars), small economic (black outlined red circles) and activity-facility (black filled triangles) sites. The Roman Via Nova is labeled on the map. The black lines extending from the Hasa villages to the villages on the Karak Plateau are the suggested routes of communication by the 'r.walk' module. The blue-red zones around these routes show the 1 km. buffer (see the legend) around these routes. Note that all non-village sites are within these buffer zones.

Figure 90 is the same map with Figures 88-89 with the exception of the view sheds from the military sites and 1 km. buffers around the possible trade routes between the Hasa and Karak villages. The sites –other than villages and military– that remain within these buffers are subjected to ANOVA for differences in size and complexity (in comparison with the same sites that are in other parts of the Hasa) in order to test whether possible participation in long-distance trade helped them to develop in ways that would be detectable archaeologically. However, the results of ANOVA for these sites are inconclusive: there is no clear indication that the sites (i.e., activity-facility or small economic) that remain within 1 km. buffer zone around the villages in the west Hasa have

grown in size or become more complex by being closely located to possible routes of trade and exchange.

Temporal Changes in Site Size and Changes in Social Organization



Figure 91. The general distribution of sites according to calculated size. The normal quantile plot on the right shows that great majority of the Hasa sites in the early metal ages are smaller in size and as site size increases, the number of sites in these categories are fewer.

The distribution of sites according to calculated size values –as explained in the Methodology chapter– creates a concave pattern in the normal quantile plot and this is significant for the discussion of social complexity. These patterns result from the presence of few large sites while the bulk of sites are much smaller. A similar pattern is visible in the histograms of Figures 83 and 85. These patterns are trademarks of settlement hierarchies, which have some indications about social organization and complexity. Especially how social transformations through increasing complexity need to be addressed. However, it should also be noted that the concave pattern in Figure 91 is

created by all of the sites (n=335) and the individual analysis of periods do not show sustained patterns similar to Figure 91.



Figure 92. The calculated site size distribution in the Chalcolithic (a) and EB IV-LB (b). The normal quantile plots in both cases do not show close similarity with the overall pattern revealed in Figure 91.

The Chalcolithic distribution of setlements (Figure 92a) according to their sizes do not create an emphasized concave pattern in the normal quantile plot. Although such pattern is slightly more obvious in the EB IV-LB (Figure 92b), the absence of a complete patterns is largely due to the sample size issue. The absence of concave pattern in the normal quantile plots for the Chalcolithic and the EB IV-LB periods is expected mainly because of low population density, which may inhibit emergence of social complexity. These results suggest that increased social complexity, its reflectance in the settlement systems as hierarchies do not occur in each period.



Figure 93. The calculated site size distribution in the EB I-III (a) and IA (b). The normal quantile plots in both cases are similar with the overall pattern revealed in Figure 91.

The patterns emerging from the normal quantile plots in Figure 93 suggest a close similarity with the concave pattern shown in Figure 91. This pattern (i.e., the low number of very large settlements and very high number of much smaller sites) is significant because it is parallel with the scale-free networks approach to evaluate and analyze the development of social complexity. As discussed in the Theory chapter, this approach adapts the perspective of how relatively well-connected few agents (i.e., sites) tend to dominate the social networks (i.e., settlement systems), which benefit them economically and politically. Consequently, their economic wealth and prestige bring political significance to these agents/nodes (or, hubs), which further contributes to their wealth (i.e., "rich gets richer") and social significance as they expand their networks in relation to the size of their roles and connections in the system (the "preferential attachment" as described in the Theory chapter). In order to explore whether scale-free network concept can be applied to the social organization of the Hasa settlement systems during the EB I-

III or IA, the site size data need to be arranged in "bins". Each bin should have a standard range (in this case, the value of the bin is square meters) and the number of sites that fall in each bin is recorded.



Figure 94. The log-log bivariate plotting of the IA number of sites (y-axis) and the site size (x-axis). Each bin on the x-axis represents 5,000 square meters originally. The data table used for this plot has 136 sites between 0-5,000 square meters –the smallest sites– whereas for the largest bin (i.e., 40,000-45,000 square meters) there are only 2 sites. Three bins have no sites in them. $R^2 = 0.88$ and p = 0.0050.

The log-log plotting of the number of sites and the site size ranges reveals a very strong correlation between the number of sites decreasing and the site size increasing among the IA settlements (Figure 94). This suggests that, under the peripheralization of the Moabite state, the Hasa develops settlement hierarchies in the IA, where few very large villages possibly act as nodes of interaction among all other sites and become

economically prosperous (i.e., "hubs" of large size), which allows them to gain social and political significance in the economic landscape of the southern Jordan.



Figure 95. The log-log bivariate plotting of the IA number of sites (y-axis) and the site size (x-axis). Each bin on the x-axis represents 5,000 square meters originally. The data table used for this plot has 73 sites between 0-5,000 square meters –the smallest sites– whereas for the largest bin (i.e., 20,000-25,000 square meters) there are only 2 sites. Two bins have no sites in them. $R^2 = 0.67$ and p = 0.3842.

The application of the scale-free networks concept (i.e., log-log plotting of the number of sites and site size) for the EB I-III site size data does not reveal equally strong correlation between these variables and the low p value rejects the argument of a possible settlement hierarchy in the EB I-III. This result reinforces the view that the Hasa settlement expansion and the development of settlement systems is autochthon in this period and under these conditions, the Hasa sites do not show sufficient complexity to

indicate the emergence of hierarchies of settlement. The settlement expansion in the EB I-III phase does not have sufficient settlement or population density or economic wealth to bring and sustain such social and political complexity. Consequently, the most important difference between the two phases of settlement expansion in the Hasa is the introduction of the settlement hierarchies –hence, complex social organization– as a factor of peripheralization and long-distance trade networks in the region, neither of which exists in the EB I-III. Thus, settlement hierarchy in the IA of the Hasa can be attributed to the Moabite peripheralization in the area for the economic, political and social incentives it offered to the Karak Plateau.

Landscape Evolution

The landscape evolution for the early metal ages in the Hasa is reconstructed by using 'r.landscape.evol' module in the GRASS, which is scripted by the MEDLAND Research Team. The module's working principle has been discussed in detail in the preceding chapter and in Barton et al. (2010). In order to maintain consistency in data, the climatic variables used in this reconstruction are taken from Ar-Rabbah weather station. Table 21 summarizes the values used for the module. The following discussion is focused on the temporal changes in the Hasa landscape, based on the changes in elevation as predicted by the landscape evolution module in GRASS.

| Period | Average Precipitation (mm) | Number of Rainy Days | R- factor | K- factor | C- factor | Soil Density | Number of Years |
|--------------|----------------------------------|-------------------------------|--------------|--------------|--------------|-----------------|-----------------------|
| Chalcolithic | 462 | 78 | 4.450 | 0.42 | 0.01 | 1.2184 | 900 |
| EB I-III | 434 | 78 | 4.457 | 0.42 | 0.01 | 1.2184 | 1,100 |
| EB IV | 405 | 74 | 4.444 | 0.42 | 0.01 | 1.2184 | 300 |
| M-LB | 372 | 70 | 4.455 | 0.42 | 0.01 | 1.2184 | 900 |
| IA | 339 | 66 | 4.475 | 0.42 | 0.01 | 1.2184 | 400 |

Table 21. The summary table showing the climatic and environmental variables used for landscape evolution modeling in the Hasa. The average precipitation is the mean value for each period, calculated from precipitation landscapes. R-factor refers to the rainfall index, which is calculated by the Macrophysical Climate model for each century and the average for each period is used here. K-factor refers to the soil erodibility, which is a set value that changes from one landscape to another. Cfactor denotes the land cover and shrubs, the common vegetation in the Hasa, has the lowest value.

The results of landscape evolution analysis in GRASS are presented using the

cumulative difference map, as explained below. Using the 'r.landscape.evol' script, slope, elevation, net accumulation and net change maps have been prepared for the main Hasa drainage (Figure 47) by running the model for the number of years specified in Table 21. In order to make temporal change (i.e., the spots of sediment erosion and deposition on the landscape) clear, the "difference map" is shown in Figure 96 below. This map is the result of a simple map algebra operation: the modern DEM (Figure 47) is subtracted from the elevation map of the last IA iteration. Consequently, the difference map is showing spots on the landscape that change elevation due to erosion/deposition events. The numbers shown on the legends is the amount of sediment eroded (minus values) and deposited (positive values) in each cell.



Figure 96. The cumulative elevation change map. This map is the result of operation (the modern DEM - the elevation map of the last IA iteration). The results suggest that erosion takes place across the drainage, especially along the Hasa main channel between the central and west Hasa. The major erosional activity takes place in the western terminus of the Hasa while the upper Hasa experiences minimal erosion.

Based on the mean erosion values in Table 22, the Chalcolithic ranks second, after the EB IV. The model shows that erosion takes place along the Hasa main channel at varying intensity. The erosion is significantly higher in the lower Hasa due to its dissected topography. The upper Hasa does not show significant erosional activity and this is an expected outcome of the model considering the dense settlement activity in this area, which may suggest that this part of the Hasa is settled densely for its relative geomorphic stability whereas highly dissected sections of the Hasa are rarely settled due to topographic (i.e., steep slopes) and geomorphic (i.e., less stability of soil cover) characteristics. The EB I-III ranks third on the basis of mean erosion values in Table 22. Erosion/deposition rates are low and this can be attributed to the wetter climatic conditions in this period as suggested by the climate data (Figure 56). Significant erosion activity continues in the As-Safi area, low-density erosion is going on in the central parts of the Hasa main channel while the upper Hasa remains stable without any significant sign of erosion.

The modeling results suggest that EB IV has the highest mean erosion rate, as shown in Table 22. Combined with the highest mean rate of deposition, the EB IV represents the period when the landscape is significantly changing and these calculations do not take anthropogenic activities into account. The majority of erosional activity is in the As-Safi area and central drainages.

The Middle and Late Bronze Age (MBA) rates of erosion/deposition are among the lowest. Based on the figures from Table 22, it is clear that the late EB represents a phase when both erosion and deposition reach peak and starting with the MBA, these rates drop. Although major erosion affects the western terminus, soil loss starts to affect the upper Hasa.

The IA has the lowest mean erosion value in Table 22, which may be a factor of severe drought in this period (Figure 56). However, landscape evolution does not consider anthropogenic activities, therefore the results require cautious interpretation.

The temporal summary of landscape evolution from the perspective of sediment erosion/deposition illustrates the scale and location of major erosion activity in the Hasa throughout the early metal ages. The most significant change, in terms of erosion, is taking place in the main channel of the Hasa from the lower Hasa to the central portion. The erosion does not significantly affect the eastern terminus or the tributary valleys, which help explaining whit these parts of the Hasa are settled more densely than the rest of the drainage.

| Period | Mean erosion | Mean Deposition | Mean Soil Depth |
|--------------|--------------|-----------------|-----------------|
| Chalcolithic | -0.00077 | 0.0020 | 1.350 |
| EB I-III | -0.00074 | 0.0021 | 1.835 |
| EB IV | -0.00099 | 0.0036 | 1.944 |
| M-LB | -0.00068 | 0.0020 | 2.266 |
| IA | -0.00056 | 0.0019 | 2.389 |

Table 22. The summary table showing the statistical results of landscape evolution models by period. The highest value in each column is shown in bold.

Erosion reaches its peak in the Hasa during the EB IV based on the figures in Table 22. The high levels of erosion can be attributed to the geomorphologic characteristics of the As-Safi region, which is below the sea level. The rate of erosion continuously drops after this period. Also, the maximum deposition is reached during the EB IV when the climate turns arid. Table 21 shows that between the Chalcolithic and Iron Age, the difference in precipitation is 123 mm of deficiency. The drainage experiences lower number of rainy days (12 days less). These changes suggest that although the actual amount of precipitation does not change much, the number of rainy days is fewer, which consequently means that later rainfall has torrential nature. Such events become the norm starting with the EB IV in the Hasa and these events significantly increase erosion and deposition. The nature of rainfall (i.e., spread out vs.

torrential) is the biggest contrast between the first and the second halves of the early metal ages. The increase in the mean soil depth after the Early Bronze IV is also supporting this, which significantly increases the depth of soil by the end of the IA as a function of such torrential rain events.

Human Impacts

The preceding section shows how environmental factors such as average precipitation, precipitation per rainfall, land cover, soil density and soil erodibility can contribute to natural processes of erosion, sediment transport and deposition in arid landscapes of the southern Jordan in the context of the Hasa. In this section, I present the results of a different analysis. Using another GRASS script 'r.agropast.extensive', which is developed by MEDLAND Research Team, I examine how anthropogenic activities (i.e., extensive land use patterns –both agriculture and pastoralist–) may affect the land cover in the Hasa. Specifically, these analyses focus on how the composition of land cover changes after set number of years of agropastoral land use in marginal environments such as the Hasa. The details on the script (i.e., which parameters are used for what reasons) are described in detail in the Methodology chapter. My analyses are based on four sites (Figure 97) that I visited and mapped in the Hasa during the fieldwork. These sites are located on plateaus (i.e., WHS 23 and 615), in the main Hasa channel –WHS 165–, and in the upper Hasa (Drainage 18, Figure 50)–WHNBS 216.



Figure 97. The Hasa sites used for extensive agropastoral land use modeling shown on the shaded relief map of the drainage. The selection of the sites reflects the diversity of land forms that Hasa sites show: plateaus, valleys and ridges.

The details on type and number of features as well as their functions and temporal associations are provided in Table 3 in the Methodology chapter. These sites are chosen for such anthropogenic impact modeling because they display variations in occupational history, function and size. Tables 23 and 24 provide information about the estimated population and size of agricultural, pastoral catchment sizes for each site.

| | Habitation | | Per person | |
|-----------|------------|------------|------------|----------------|
| Site | Units | Population | area (ha) | Site Area (ha) |
| WHS 23 | 18 | 90 | 1.36 | 122.4 |
| WHS 165 | 2 | 10 | 1.36 | 13.6 |
| WHS 615 | 8 | 40 | 1.36 | 54.4 |
| WHNBS 216 | 2 | 10 | 1.36 | 13.6 |

Table 23. The summary table showing the number of habitation units, estimated population, coefficient for population and site size for each site used in modeling.

| Site | Slope Threshold (degrees) | Agricultural catchment (Ha) for 20% farming | Pastoral catchment (Ha) for 50% |
|-----------|------------------------------|--|------------------------------------|
| WHS 23 | 20 | 647.1 | 970 |
| WHS 165 | 20 | 73.3 | 1,046 |
| WHS 615 | 20 | 282.5 | 1,017 |
| WHNBS 216 | 20 | 67.4 | 1,092 |

Table 24. The summary table showing the sizes of agricultural and pastoral catchments for each site used in modeling. For calculations of agricultural catchment area, sloping terrains of 20 degrees or higher are excluded around each site. Terrains steeper than 20 degrees are rarely used for farming (Table 8) however steepness is not an issue for pastoral land use.

Based on the figures provided in Table 24, the catchment areas of corresponding sizes are created around each site in GRASS and these sites are subjected to 50 years of extensive agropastoral land use. In an attempt to reflect the scale and extent of anthropogenic impacts on the land that has been settled longer, the site of WHNBS 216, which is located in the Drainage 18, is also modeled for 200 years of human land use. In the following section, two maps are provided for each site: one for agricultural and one for pastoral land use. Following the maps, I present the data on how the land cover changes. The legends show land cover classes and these are repeated as many times as they are allowed in the rules files of the script, as explained in the Methodology chapter. Each repeat counts for a year.

<u>WHS-23:</u>



Figure 98. The map showing the principal land cover classes at WHS-23, which is located on the southern plateau of the Hasa, after 50 years of extensive agricultural land use. Moderately sparse grassland becomes the signature land cover type in the Hasa. The arable land is 12 Ha. and 627.5 Ha. of land is in fallow at the end of the final iteration.



Figure 99. The map showing the primary land cover classes at WHS-23 after 50 years of extensive pastoral land use. The legend from Figure 98 applies to the redgray section at the center of the image. However, the pastoral catchment is much wider (Table 24). Grass and small trees become the typical land cover type in the Hasa.

<u>WHS-165:</u>



Figure 100. The map showing land cover classes at WHS-165, which is located in the main Hasa channel after 50 years of extensive agricultural land use. Moderately sparse grassland dominates the land cover. The arable land is 1 Ha. and 72.2 Ha. of land is in fallow at the end of the final iteration.



Figure 101. The map showing land cover classes after 50 years of extensive pastoral land use. The legend from Figure 100 applies to the red-gray section at the center of the image. Note the size of the grass and small tree type of land cover, which becomes typical in the Hasa.

<u>WHS-615:</u>



Figure 102. The map showing land cover classes at WHS-615, which is located in the east Hasa, in the valley of el Ali. Moderately sparse grassland is the main land cover type after 50 years of extensive agricultural land use. The areas where the shaded relief can be seen through the agricultural catchment represent the parts of the landscape at the site where the slope is greater than 20 degrees (Table 24). The arable land is 7 Ha. and 269.6 Ha. of land is in fallow at the end of the final iteration.



Figure 103. The map showing land cover classes at the site after 50 years of extensive pastoral land use. The legend from Figure 102 applies to the red-gray section at the center of the image. As the figure shows, the degree of slope does not inhibit pastoralist activities.
WHNBS-216:



Figure 104. The map showing land cover classes at WHNBS-216, which is located in the North Bank, in Drainage 18, after 50 years of extensive agricultural land use. Moderately sparse grassland has become the principal land cover. The arable land is 1.5 Ha. and 65 Ha. of land is in fallow at the end of the final iteration.



Figure 105. The map showing land cover classes at the site after 200 years of extensive agricultural land use. This type of land use does not cause significantly different land cover in the Hasa, in the long-term (Figure 108). The arable land is 1 Ha. and 64.7 Ha. of land is in fallow at the end of the final iteration.



Figure 106. The map showing land cover classes at WHNBS-216, after 50 years of extensive pastoral land use. The legend from Figure 104 applies to the red-gray section at the center of the image. Grass and small trees have become the characteristic land cover following this type of land use.



Figure 107. The map showing land cover classes at the site after 200 years of pastoral land use. The legend from Figure 105 applies to the red-gray section at the center of the image. Note the differences caused in the land cover composition by long-term extensive pastoral land use. Although grass and small trees are common, grassland and shrubs are also significant (Figure 109).



Figure 108. The bar chart comparing the percentages of principal land cover classes after extensive agricultural land use in the Hasa. The y-axis shows percentages of each land cover class at sites modeled. The sites are color-coded (see the legend), which are arranged from the west to the east.

The results of extensive agricultural land use modeling for the Hasa have important implications for the human impacts in the marginal environments such as the Hasa. Firstly, the results in Figure 108 show that very sparse and sparse grasslands become the primary land cover types (Figures 98, 100, 102, 104, and 105) after extensive agricultural land use. Secondly, the percentages shown in Figure 108 suggest that the length of extensive agricultural activity (i.e., 50 years vs. 200 years) is not a factor for the emergence of land covers, with the exception of bare lands. It is clear from the percentage values that the longer lands remain under extensive agriculture, the smaller areas of bare land they have. Finally, neither the landform (i.e., plateau, valley, or ridge) nor the location of the site (i.e., the west or east) seems to be a factor in the land cover classes that emerge due to extensive agriculture in the Hasa. Considering the different sizes of agricultural catchments (Table 24), the implications of these patterns become firmer.



Figure 109. The bar chart comparing the percentages of principal land cover classes after extensive pastoral land use in the Hasa. The y-axis shows percentages of each land cover class at sites modeled. The sites are color-coded (see the legend), which are arranged from the west to the east.

The results for the extensive agropastoral land use in the Hasa on the other hand suggest very different patterns (Figures 99, 101, 103, 105, and 106). Figure 109 summarizes these patterns efficiently by comparing the sites. Firstly, the differences in diversity of land cover after extensive pastoral land use is evident from the chart: unlike agriculture, the land cover has greater diversity (i.e., four land cover classes in Figure 108 vs. seven land cover classes in Figure 109) as a result of pastoral activity. This emphasizes the ecological significance of pastoralism -in addition to its economic value as complementing agricultural subsistence patterns- especially in marginal landscapes, since this land use has the potential to introduce and increase diversity in vegetation. Secondly, differences of land cover classes based on site size (i.e., the number of features, area of settlement, and population in Table 23) are apparent from Figure 109. WHS-23 (red in Figure 109) is the only village that is modeled for human impacts and the results of pastoral land use suggest that the village mainly has very sparse/sparse grassland. The lack of small trees or even maquis around the site may be a factor of its size and population.

The remainder of modeled sites is much smaller and consequently, the land cover consists mainly of grass and small trees. Thirdly, the east-west sites do not show a significant difference in terms of vegetation although it is shown that the west Hasa receives less rainfall than the west based on the data from the weather stations around the Hasa (Figure 56): WHS-165 (green in Figure 109) have comparable values with WHS-615 (blue), and WHNBS 216 (yellow). However, the length of pastoral activity, unlike agricultural land use, can change the composition of vegetation at a site. The long-term

(i.e., 200 years) extensive pastoral modeling of WHNBS-216 (light green in Figure 109) shows that under such land use patterns, sites may show higher percentages of maquis and sparse small trees. Thus, the results of extensive pastoral model suggest that sites of larger size can create sparse grassland environments whereas the environment around smaller sites that have long-term pastoral land use can have mainly maquis or sparse tree vegetation. An additional factor of long-term pastoral land use that needs to be emphasized here is the range of diversity in land cover classes. The results of 200-year model at WHNBS-216 show that this group has more significant percentage –30.14%– of other (i.e., moderate grassland, grassland, grassland and sparse shrubs, grass and shrubs) land cover classes in comparison with the results of 50-year model for the same land cover classes –3.34%–, at the same site.



Figure 110. The line chart representation of data presented in Figure 109. The differences of land cover classes between the village (WHS-23) and small economic sites (WHS-165, WHS-615, and WHNBS-216) are visible.

The comparison of the percentages of land cover classes in a line chart (Figure 110) reveals visually explicit patterns of change in vegetation as a result of extensive pastoral land use in the Hasa. Although all modeled sites reveal a roughly similar pattern

(i.e., a plateau for sparse grassland and an S-curved change from grass and sparse maquis to grass and small trees), the only village site (WHS-23, red dotted line in Figure 110) shows highly exaggerated patterns for such changes. WHS-165 (green solid line) and WHNBS-216 (red solid line), on the other hand, are fairly close to each other in terms of modeled percentage area of land cover classes. WHS-615 (blue solid line) however, is between these two groups for its land cover classes and this is a factor of size: this site is the second largest settlement modeled for impacts of pastoral land use (see Table 23). The result of long-term pastoral land use at WHNBS-216 (black dotted line) mimic the patterns for the short-term model in terms of sparse grasslands. On the other hand, the patterns significantly change for other land cover classes. In the long-term use of land for grass and maquis and grass and sparse small trees. The reduced significance of grass and small tree class of vegetation is due to the length of pastoralist activities at the site.

The results of extensive agropastoralist land use model applied to a diverse group of early metal age sites in the Hasa show that the size of site and the duration of anthropogenic activities are important factors in the scale and extent of changes in land cover in marginal landscapes (Table 23 and Figure 110). Although differences in land cover classes are subtle and the diversity of vegetation is significantly low under extensive agricultural land use (Figure 108), major changes in the vegetation around a site is brought by extensive pastoralist land use (Figures 109 and 110). The modern day land cover classes in the drainage agree well with the results of the land use model above. The changes in land cover due to anthropogenic activities (i.e., extensive agropastoralism) can also be measured in how such changes affect the erodibility of soil in the Hasa. The human impacts modeling in the Hasa assumes three major land cover classes, as explained in the Methodology chapter: bare land, grassland, and grassland with small trees. These land cover classes can be assigned a cover-management factor (i.e., the c-factor used in the landscape evolution section), which also makes quantification of the anthropogenic impacts on the landscape possible. The extensive agropastoral models applied in this research used the following values: 0.1 for bare land, 0.05 for grassland, and 0.009 for grass with small trees. As the values suggest, the best land cover type to resist erosion in the Hasa is grass with small trees, bare land is easily erodible since there is no land cover protecting the soil whereas grasslands lie in between.



Figure 111. The bar chart comparison of c-factor values at sites based on the results of extensive agricultural land use modeling. Bare land to Grassland category has c-factor values between 0.1 and 0.05, Grassland to Sparse Trees category has the range of 0.049 and 0.09. The y-axis shows percentages of each category at sites modeled.

Based on the distribution of c-factor values at each site in Figure 111, it is possible to suggest that agricultural activities in the Hasa –even if they are extensive in nature– cause sufficient land cover change that increases risk of erosion. The results do not imply differences in c-factor values based on landform, size, or location in the drainage (i.e., east or west Hasa). These results agree with the data presented in Figure 108, which illustrates that extensive agricultural land use in the Hasa usually creates very sparse/sparse grasslands. The length of extensive agriculture is not a factor that changes c-factor.



Figure 112. The bar chart comparison of c-factor values at sites based on the results of extensive pastoral land use modeling. Bare land to Grassland category has c-factor values between 0.1 and 0.05, Grassland to Sparse Trees category has the range of 0.049 and 0.09. The y-axis shows percentages of each category at sites modeled.

The results of extensive pastoral land use on the other hand, suggest that this kind of land use has the potential to reduce risks of erosion associated with agriculture by increasing the vegetation diversity (Figure 109) in much larger catchments (see Table 24) and producing land cover that is between grassland and grassland with small trees (Figure 112). However, these positive contributions of extensive pastoralism largely depend on the size of the site. As it is the case with Figure 109, Figure 112 also shows the destructive capacity of larger settlements on the landscape. The activities in WHS-23 (red in Figure 112), the only village modeled, show increased risk of erosion due to large areas of very sparse grassland created (Figure 109). A similar –but to a lesser scale– event is observed at WHS-615 (blue in Figure 112), which is the second largest settlement modeled for human impacts on the landscape. The remainder of sites changes the land cover around sites to a type that has higher resistance to erosion (i.e., grassland or grassland with small trees), which is a factor of site size when pastoralism is considered: as stated above, site size is not a factor in agricultural land use (Figure 111). The length of extensive pastoralism is not a factor in changing c-factor.

The combined effect of agropastoralism on the land cover and its reflection as cfactor in terms of human impacts on the landscape show that the impacts of agriculture (i.e., increased risk of erosion) can be mitigated and subsistence patterns are sustainable in terms of environmental impacts. This also emphasizes another benefit of incorporating pastoralism into agriculture. Pastoralism has the potential to lower the risk of erosion if kept at smaller scale and pursued as complementary to agriculture. Based on the results of human impacts analyses, it is possible to suggest that these benefits of extensive pastoralism diminish swiftly when the sites in marginal environments like the Hasa, exceed a threshold between 54 and 122 ha. (Table 23, Figures 109 and 112). The results of anthropogenic impacts, through extensive agropastoral modeling, support the comparably less destructive aspect of extensive economic systems in relation to intensive land use systems. Such extensive subsistence patterns are integral parts of tribal social systems. Besides creating a self-sufficient and sustainable economic system for agropastoralists, such land use patterns also make tribes resilient against major perturbations such as drought and erosion. The next section will elaborate on the resilient aspect of tribal settlement systems and attempts to define "resiliency" using the settlement systems.

New Settlements and Resiliency

The concept of 'new settlements' reflects the highly resilient nature of the Hasa settlement systems. This concept is simply comparing the total number of sites in one period with the number of sites that has not been settled before (hence, new sites). In short, the new settlement refers to the number of sites that start occupation from ground zero in each period. Since the research results indicate that the environmental conditions in the Hasa are deteriorating gradually and continuously while the settlement systems and subsistence show oscillations from one period to another (Table 5 and Figure 3), a measure that can evaluate the resiliency of the early metal age settlement systems in the Hasa is necessary. Using the new settlement counts, I develop a measurement of the resiliency, which then can be related to socio-economic adaptations as reflected in settlement systems. A complementary measure to the new settlement is the 'continuing sites'. Since new settlement concept ignores any site that is occupied previously, using the continuing sites, a separate measure is developed, which can be used to illustrate what

kinds of sites become desirable in later periods, as the environment, social and economic organization in the Hasa are co-evolving.

| Period | Total Sites | New Sites | Continuing Sites | Change- Settlement Activity (%) | Change- New Settlement Activity (%) |
|--------------|-------------|--------------|---------------------|--|---|
| Chalcolithic | 37 | 37 | 0 | 240 | 100 |
| EB I-III | 77 | 71 | 6 | 137.84 | 92.2 |
| EB IV-LB | 21 | 13 | 6 | -72.7 | 61.9 |
| IA | 165 | 131 | 33 | 675 | 79.3 |
| IAII | 12 | 12 | 0 | 9.1 | 0 |

Table 26. The number of total, new and continuing sites in each period.

| Factor | Median Water Acc. | Median Dist. to Water | Median Precip. (mm) | Locale | Size (sqm) | Complexity | Slope | Landf. | Site Type |
|---------------------------------|---|---------------------------------|--|---|--|---|-------|---------------------------------------|-----------------------|
| Anew EB | Vllg 9 cells CV= 0.52, SmEc 9 cells CV= 1.39 | Vllg 168 m, SmEc 219 m | Vllg 322 mm, SmEc 195 mm | C, W Hasa, Drainage 18 | Up to 5,000 sqm, SmEc less than 3,000 | 1-3 features mostly, including SmEc sites | 1, 2 | Valley, ridge | SmEc, A-F, Vllg |
| Anew EBIV- LB | 10 cells CV= 3.09 | 466 m | 214 mm | West Hasa | Up to 3,000 sqm | Mostly single feature, max 3 | 2, 1 | Valley, ridge, level terrain | SmEc |
| Cont'd .EBIV- LB | 14 cells CV= 1.05 | 321 m | 75 mm | West Hasa | Up to 5,000 sqm | Mostly single feature, max 4 | 1, 2 | Ridge, valley | SmEc, Mltry |
| Anew IA | Vllg 13 cells CV= 2.23, SmEc 11 cells | Vllg 483 m, SmEc 260m | Vllg 268 mm, SmEc 94 mm | SmEc Drainage 18, Vllg Southern Plateau | Up to 5,000 sqm, VIIg >10,000 | Mostly 1-3 features, Vllg 8 or more | 1, 2 | Valley, ridge | SmEc, Vllg, A-F |
| Settled only EB and IA | Vllg 8 cells CV= 0.62, SmEc 9 cells CV= 0.79 | Vllg 168 m, SmEc 536m | Vilg 137 to 83 mm (-54 mm), SmEc 154 to 110 (- 44 mm) | Southern Plateau | Up to 5,000 sqm in EB, >10,000 in IA | Mostly up to 3 features, few IA sites have 4 or more | 1, 2 | Level Terrain and ridge | LgEc, SmEc |

Table 27. The summary table for the characteristics of anew and continuing settlements between EB I-III and IA. (*) denotes median values.

The trends in new settlements and reoccupation in the phases of settlement expansion (i.e., EB I-III, IA) and abandonment (i.e., EBIV-LB) are summarized in Table 27 where vital environmental (e.g., slope, precipitation, water accumulation) and socioeconomic (e.g., site size, type, and complexity) variables are compared. Based on the information in Table 27, certain observations can be made about the nature of new settlements and continuing sites. First EB I-III and IA periods are discussed for the characteristics of new and continuing sites, then EB IV-LB period is compared to these trends.

The median precipitation value for new EB I-III (220 mm) is close to the overall median precipitation value for this period since majority of sites are new in EB I-III. The overall IA median precipitation is 134 mm and the new IA settlements show a slightly lower value (111 mm). However, there is a striking difference between the precipitation values of new villages (268 mm) and small economic sites (94 mm). The difference in precipitation between new villages of the EB and IA is significant (54 mm more in EB) but small economic sites show greater difference (101 mm more in EB). These differences support the expectation that the EB settlements have higher capacity of economic stimulus in the IA besides agropastoralism in order to support the large population in the Hasa, such as the long-distance trade and peripheralization of the Hasa in the IA (as discussed earlier in this chapter). This is also the reason for IA villages selectively occupying the Southern Plateau: for climatic and economic (i.e., trade)

purposes. The continuing villages from EB I-III to IA show a precipitation deficit of 54 mm. This deficit is 44 mm for the small economic sites.

The new EB I-III sites are located more closely to water sources (230 m) in comparison with the new IA sites. The overall median distance for IA sites is 300 m. However, there are variations between IA villages (483 m) and small economic (260 m) sites. The data suggest closer proximity of EB sites -both villages and small economic sites- to water sources. Especially the proximity of EB villages signifies their economic value for the settlement systems of this period. The IA new settlements' distances to water sources provide further support to the idea that the villages are located farther from water sources as they are located on plateaus with higher rainfall whereas the small economic sites are located closer to water sources since they are mostly in the eastern terminus of the Hasa, which receives less rainfall. Such temporal differences indirectly support the results about additional economic activities in the IA –i.e., long-distance trade as discussed above, which create an incentive for peripheralization of the Hasa and make dense settlement in the Hasa possible and feasible. The water accumulation rates at new EB I-III sites are lower than the new IA settlements. Although the difference is not significant for the small economic sites, it is noticeable for the villages. This difference can be explained in terms of increase in erosion due to prolonged aridity and possibly human activities (see the Human Impacts section in this chapter). Although villages of this period are usually on plateaus, some sites are located in valleys where erosion increases accumulation at certain sites.

The new site compositions in EB I-III and IA are similar and continuing sites from the first phase of settlement expansion (i.e., EB I-III) into the second (i.e., IA) consists of villages and small economic sites. These patterns suggest that during phases of dense settlement activity, Hasa witnesses significant increase in small economic sites and as part of the changes in land use and subsistence (i.e., extensive economy), the social organization changes, which is illustrated by the emergence of villages (Figures 94-95). New sites of EB I-III, IA and continuing sites from one phase to the other occupy valleys and ridges. The avoidance for high-risk landforms to lower risks of erosion is illustrated in the practice of settling flat or slightly sloping lands, which is also a factor of extensive economic organization. These three groups of sites (i.e., new EB I-III, new IA and continuing sites from EB I-III to the IA) also show a similar pattern in terms of internal complexity: the new settlements display wider ranges in terms of the number of features at sites. Although EB I-III new small economic sites still have lower internal complexity, the higher number of features is observed in the new IA villages. The continuing sites show that the internal complexity increases with the IA. The new and continuing sites of the high settlement density periods (i.e., EB I-III and IA) also show common aspects in terms of size: wider range of size is observed for the EB I-III although small economic sites remain small in general (Figure 93a). The increase in site size can be attributed to the increased frequency of villages in the IA. The continuing sites on the other hand show increase in size during the IA (Figure 93b). Although new sites of EB I-III are usually found across the Hasa, they are clustered in Drainage 18 (Figures 50-51). This is also true for the IA small economic sites whereas the villages of this period prefer the Southern Plateau. The Southern Plateau is also the chosen location for the continuing sites from EB I-III to the IA.

The new EB IV-LB and resettled EB IV-LB (from EB I-III period) patterns reveal that these sites –mostly small economic and military– usually prefer valleys, ridges and choose flat or slightly sloping terrain, which are located in western Hasa. The complexity level is either very low in new sites or is reduced significantly during the resettlement, which also applies to size variable. The new EBIV-LB sites receive significant precipitation, which can be attributed to multi-modal settlement distribution in this period (Figure 70 and Table 16). The resettled sites on the other hand, have much lower precipitation values and this shows the willingness to occupy these sites. The locations (i.e., protected) or other resources around these sites seem to be the driving factor for resettlement since precipitation is low. The distance to water sources and water accumulation rates suggest that the resettled sites during the abandonment phase are closer to water sources with higher sediment accumulation rates. Considering the low precipitation values for this group, it is possible to suggest that resettled sites -for whatever reason they are picked- are located near water sources or controlling important spots on the landscape such as defensive locations, both of which are important factors in this period. The new sites on the other hand are far from water sources and water accumulation rates are not nearly high. These patterns suggest that the new sites –which are mostly small economic sites- have different economic orientations such as pastoralism, as indicated by multi-modal elevation distribution and vertical land use

patterns. These make proximity to water sources not a considerable factor in locating EB IV-LB sites.

Chapter 7

CONCLUSION

Introduction

This research on the shifting settlement patterns of the early metal age communities in the Wadi el-Hasa as a case of social, economic and political adaptation to changing climatic and environmental conditions, both as a result of natural and anthropogenic factors have been discussed and assessed within the interpretive framework of the Hasa Synthesis, which is described in the theory chapter. The concluding remarks in this chapter start with a review of the Hasa Synthesis. Then, I will contextualize the most important results of my research on the changes in settlement systems and social organization in order to explain the cycles of abandonment and resettlement in the area. I focus on how the inhabitants of the Hasa adapted to changes that affect their survival on the marginal Hasa landscape through various social and political mechanisms. Finally, I discuss the contributions of this research for archaeology in particular, and for the social sciences in general as well as outlining the possible venues for future research.

The Hasa Synthesis

The Hasa Synthesis is an explanatory framework, which contextualizes the social and economic behavior of tribal groups that live in marginal lands. In such areas, population density cannot reach the threshold that brings hierarchic social complexity due to environmental conditions (i.e., dissected topography, low rainfall, thin soil profiles, presence of xeric vegetation), the social dynamics remain fluid (i.e., tribal groups fission or fusion), and the subsistence largely relies on nomadic pastoralism, which further contributes to the high mobility patterns of tribes. The Hasa fits this description well and consequently, the research results can be assessed in terms of how well they fit the expectations of the Hasa Synthesis.

The Hasa Synthesis views abandonment as a social reorganization within the concept of heterarchic system, where tribal groups (i.e., kinships or lineages) maintain diverse economic base, keep the social dynamics among themselves fluid. This allows different tribes to aggregate when economic maximization is feasible socially, politically and environmentally. Therefore, population aggregation (i.e., group fusion) is an attempt to increase the marginal productivity that ensures the survival of lineages on the landscape through cooperation. As aggregation takes place and economic maximization leads to accumulation of wealth, social change takes place (i.e., scalar communication stress and scale-free networks) and social inequality emerges in heterarchic systems. During this aggregation phase, communities not only benefit from producing more but also reap additional benefits of surplus through establishing exchange relations, which adds other dimensions to social change.

In the archaeological record, such aggregation is reflected as increased settlement density, wide variations in site types and the emergence of administrative and economic centers (e.g., villages and towns). The change in these conditions and reversal of aggregation is possible by changes in any or a combination of factors that initially made aggregation and cooperation feasible. Among them is the environmental change (i.e., due to natural factors) or anthropogenic degradation (i.e., including unintended consequences of human activities on the landscape). Once such changes start to affect the marginal productivity of aggregated tribes, the conditions that favor aggregation are negated. The diminishing economic gains and social conflicts may make fissioning of groups more desirable especially because people cannot benefit (i.e., economically or socially) from tribal cooperation. Once the fission (i.e., group dispersal) starts, the tribes become economically self-sustaining, politically autonomous units. Reduced resource availability may increase inter-group conflicts through time and group fission may mitigate such tensions by settlement dispersal. In the archaeological record, population dispersal phase can be identified from lower settlement density, reduced site type diversity, and lack of large settlements. Due to tribal competition for limited resources, trade activities are largely suspended, which adds to the economic problems. The subsistence system changes from agropoastoralism of the aggregation phase to mainly pastoralism. Such shifts in the economic organization of the society are responses to environmental (i.e., aridity) and political (i.e., eluding central authority) stress factors, which might have caused drop in the marginal productivity at the first place.

By reducing the group size, spreading across the landscape and by either diversifying (i.e., more pastoralism with less agricultural component) or completely changing (i.e., transhumant pastoralism) the economic base, tribes attempt to increase the marginal productivity, keep conflicts at bay and survive the stress factor. The heterarchic socio-economic structure facilitates survival and flourishing of tribal groups in marginal landscapes where hierarchic formations cannot respond to stress factors due to their rigid social structure and inflexible subsistence system that relies heavily on agriculture.

The Fit Between Research Results and The Hasa Synthesis

Environment:

The Hasa landscape mainly consists of flat and slightly sloping land; the predominant landforms are ridges, valleys, and level terrains, which humans mainly prefer for settling between the Chalcolithic and the Iron Age. The Hasa profiles show that the western half of the drainage is highly dissected especially around As-Safi, creating deep valleys, gorges and exhibiting significant elevational (between 200 and 1,200 masl) and environmental (mesic to xeric) variations. The eastern half, on the other hand, especially the eastern terminus of the Hasa, has relatively less incised landscape, and elevational and environmental variations are less significant. The eastern terminus has deflated surfaces and xeric vegetation today, favored by pastoralists, whereas the west Hasa is more suitable for farming.

In terms of the settlement systems, such wide topographic variations across the Hasa suggest that the communities have access to resources that are limited in quantity – due to the marginal environmental conditions in the area– and spread out on the landscape (i.e., scattered across the drainage), which consequently makes it difficult to pursue economic maximization through intensive agropastoral production. Although it is necessary to consider the natural and cultural formation processes that may destroy archaeological sites post facto, the fact that the settlement activity –with diverse types of sites– mostly focuses on the eastern terminus and central drainages suggests that the inhabitants of the Hasa deliberately avoid the high-risk zones for erosion (i.e., highly dissected areas, steep slopes) and expand the settlement systems on relatively more stable

landforms, which constitutes the environmental basis for the adoption of the extensive economic organization in these periods.

Climate:

The climate model and the data from four weather stations around the Hasa indicate that the warm and wetter climate of the Chalcolithic gradually becomes drier. This climatic trend emerges around the late EB (ca. 2,300 BC) and aridity progresses into the Iron Age, which has the most arid climate. Furthermore, the temperature remains stable throughout the early metal ages indicating that, coupled with reduced precipitation; the evapotranspiration is greater later in the Bronze and Iron ages. This brings significant deficiencies in rainfall in an already transitional landscape from the semi-arid (west) to the desert (east). The results of analyses show that these shifts in the climate have some impact on the settlement systems.

Throughout the warmer and wetter EB I-III, as in other parts of the southern Levant, the Hasa settlement systems show increasing social complexity (i.e., villages), denser population and settlement activity, as well as diversification of human activities (i.e., increased site type variation). With the onset of aridity at the end of the EB, the Hasa witnesses large-scale depopulation and abandonment. It is plausible that the inhabitants move to areas where climatic conditions were better (i.e., with more precipitation); among these places, the Karak Plateau is the most plausible option. The archaeological data imply that the hierarchic social organization on the Plateau survives this environmentally challenging period and quickly recovers from the economic decline of the late EB in the Middle and Late Bronze ages (Miller 1991, Hill 2006). Explaining the abandonment and depopulation solely through climatic change is not accurate however, since the Hasa settlement system revives and reaches its most dense occupation phase during the IA, which is the most arid era of the early metal ages. Even minor changes in climatic variables can have profound effects on communities that rely on agropoastoralism and that cannot produce surplus. Hasa is a good example of such communities. Consequently, the late EB abandonment of the Hasa, as the climate turns arid, is an expected outcome whereas the sudden and large-scale, complex revival of the settlement systems in the IA is unanticipated. The possible reasons for the IA events and their possible impacts on the settlement systems are discussed in detail under peripheralization section.

Under the climatic conditions summarized above and discussed in detail in the previous chapter, most of the earlier (i.e., Chalcolithic and EB I-III) settlements receive annual precipitation of at least 200 mm by remaining in a well-defined elevation range (between 700 and 1,000 masl) –the single modality previously noted. It is important to note that even during the first phase of significant population increase, aggregation, and dense settlement activity (i.e., EB I-III), people prefer to utilize only certain parts of the Hasa and densely occupy relatively more stable landforms. This suggests a preference for extensive economic organization and deliberate avoidance of maximization through intensification (i.e., incorporating landforms into settlement systems that are prone to higher rates of erosion and pursuing intensive economic production on these for short-term gains). This relates to the risk minimization and management of critical resources,

especially arable soil, for long-term sustainability, which is a common strategy among the tribes in the southern Levant.

Following the changes in precipitation regime, especially after EB IV, the settlement trends are modified; the majority of EB IV-LB sites receive annual precipitation of 160 mm or less. The elevation distribution of later period sites shows multi-modality (i.e., incorporation of higher altitude lands into the earlier settlement systems that largely focused on mid-high elevation lands), which can be attributed to aridity. These changes in the settlement systems are best illustrated by the EB IV-LB distribution of sites, which indicates that the inhabitants of the Hasa are active in three different elevation zones across the landscape –as one moves from south to north the elevation of sites drops– and adjust their land use patterns under new environmental regime. Based on the climatic and archaeological data (i.e., types of features, site size, internal complexity at sites) from this period, it is clear that the remaining few households in the Hasa are largely pastoralists.

Multi-modality in the elevation of settlements continues into the Iron Age under different socio-political conditions and continued aridification. The settlement pattern in this period reveals that high elevation terrain are reserved for large economic sites (i.e., the villages on the southern plateau) whereas others –small economic, activity-facility sites– continue to utilize mid elevation terrain. This clear differentiation supports the continuing extensive nature of settlement patterns in the region (i.e., vertically spread settlement). The preferred landforms and site types recorded are parallel with the EB I-III –but EB I-III settlements remain in a narrower elevation range (i.e., horizontally spread).

The Iron Age represents a phase when the population in the Hasa is suddenly increasing and settlement density reaches its peak, whose political and economic implications are discussed below, and these changes bring shifts in economic organization; from the EB I-III extensive economic system in the Hasa to the peripheral economy in the IA that focuses on pastoralism and long-distance exchange at varying elevation bands and using various resources. Especially during periods of population aggregation and settlement expansion (e.g., EB I-III or IA), the inhabitants continue to use wide variety of landforms; resource extraction/use (i.e., high site type diversity), and settlements preserve their small scale (i.e., low internal complexity), which focus on agropastoralism at extensive scale. These qualities of the early metal age settlement dynamics in the Hasa agree well with tribal land use patterns that mainly focus on risk management, choosing long-term survival over short-term maximization, and resilient social and economic base (i.e., pastoralism driven agriculture), all of which allow groups to adjust their size (i.e., group fusion and fission) and scales of economic activities (i.e., more pastoralist or agricultural component) according to changing environmental and socio-political conditions.

The IA illustrates this mechanism especially well because the settlement expansion and population aggregation takes place under adverse environmental conditions. It is clear from the environmental data that the climatic conditions could not support large population only with agriculture and pastoralism. This implies the existence of a new economically benefiting activity at this time, which is the inter-regional trade in the west Hasa. Consequently, the IA socio-political changes and settlement systems need to be discussed in a different socio-political context, which is peripheralization of the area.

Settlement Density and Subsistence System:

The settlement density in the Hasa increases significantly during the EB I-III and IA. These two periods are different in terms of scale of settlement with the latter having a denser and the more widespread occupation. However, the settlement systems in both periods are the same in terms of site diversity: small economic sites lead the distribution while the wide variety of sites imply establishment of broader economic basis, which mainly rely on agropastoralism. The proportion of agriculture to pastoralism is constantly changing in tribal societies living in marginal lands (Marfoe 1979) like the Hasa. As groups feel pressure from environmental or political variables, they adjust the composition of their subsistence so that the group's economy becomes flexible and can keep up with social fluidity (i.e., becoming mainly pastoralist as groups fission) (Johnson 1982: 403). Based on the settlement data and the analyses presented, the demographic characteristics of the Hasa population between the Chalcolithic and the IA can be summarized as shown in Table 5.

A second important similarity between the phases of dense settlement is the lack of association between certain site types with specific landforms –with the exception of military sites in one period. This, as well as the persistent preference for flatlands and slight slopes over steeply sloping lands for settling, clearly indicates that the inhabitants of the Hasa use caution about where they settle regardless of the intensity of settlement activity. Even during population aggregation, settlement expansion under warmer and wetter conditions in the EB I-III, which offers more suitable conditions for economic intensification than arid IA, the inhabitants of the Hasa continue avoiding unstable landforms that are highly susceptible to erosion. However, the absence of economic maximization should not be interpreted as complete lack of human impacts on the Hasa landscape because pastoralism can create equally –or, more so– devastating impacts on the landscape, in comparison with intensive agriculture. Rather, it is meant that the tribes of the Hasa adapted a land use system, which will be discussed in detail below.

The settlement density, consequently the site type diversity, is dramatically reduced during the period of abandonment and depopulation in the Hasa. Although this period is roughly similar to the Chalcolithic in terms of low settlement density and medium site type diversity, the climatic conditions of the Chalcolithic are far better (i.e., high amount of rainfall) and more suitable for farming. The leading site type of EBIV–LB is small economic settlements; especially the progressing aridity makes agricultural activities highly unlikely and difficult to pursue. EBIV-LB settlement density, site type diversity and archaeological data (i.e., site plans, features identified at sites) indicate the presence of small, mainly pastoralist communities in the Hasa.

Peripheralization:

The comparison of the EB I-III and IA settlement systems help in understanding the nature of increasing settlement density and the apparent settlement hierarchies in either period. These can be contextualized as local/autochthonous or external/imposed. Given the wetter environmental conditions and the Chalcolithic agropastoral land use, the EB I-III population increase seems to be gradual. The internal complexity of EB I-III sites drops from the previous period and it becomes persistent through out the following periods. This is expected since the economic orientation is not intensive and only very few villages emerge in this phase. The population density, site complexity, as well as the low frequency of villages support the local (i.e., autochthonous) nature of development in settlement systems.

The IA settlement systems, on the other hand, provide a completely different picture. Following a major de-population and abandonment for a long period of time (i.e., between the EB IV and LB), the Hasa witnesses rapid and significant increase in population. It is obvious from the archaeological data that Hasa does not have sufficient population density from the previous periods in order to create the high IA density from internal growth alone. Therefore, the majority of the IA inhabitants of the Hasa are probably of foreign origin, possibly migrating from the north, where the earlier population might have sought refuge when the late EB depopulation and abandonment started. These sudden changes in population and settlement density point to the fact that the Hasa becomes a periphery of the northern plateau, which sustains high population densities through out the Bronze Age and witnesses the rise of the Moabite state, one of the first territorial political entities in Transjordan during the IA (Herr 1997, Bienkowski 2001).

Additionally, the distribution of IA sites on the landscape suggests an almost polarized distribution. With the exception of few sites, small economic settlements are heavily clustered in the eastern terminus. This sector of the Hasa seems to have been a desirable locale for agropastoralists, who have direct interactions with the environment (i.e., producers). The large economic sites, which imply imposed settlement hierarchy. on the other hand are located almost exclusively, on the southern plateau. Although these settlements, which act as centers of political and economic activity, require better climatic conditions to support higher number of people, the determining factor behind locating these villages on the southern plateau is the emergence of the long-distance trade network in the IA. The caravan trade that extended from the Arabian Peninsula and reached the Mediterranean coast via As-Safi (Finkelstein 1992, 1995). This is probably the route for the trade between the Hasa and Karak Plateau as well.

The peripheralization of the Hasa also explains why the large economic sites in the Hasa are actually smaller than their counterparts on the Karak Plateau. The population and settlement density never catches up the levels in the north and in the marginal lands like the Hasa, these villages usually are the locales of tribal leadership and nodes of administration that are established or encouraged by the colonizing political entity. The villages on the southern plateau do not seem to become marketplaces because of their distance to most of the small economic sites –located around the eastern terminus– but they possibly are active and economically benefiting from trade due to their proximity to routes leading to north. The Hasa then becomes attractive to the Moabites, not only for its capacity in pastoralism, which complements the heavy agriculturalist economy of the Karak Plateau, but also for the passage of the caravans that represent an economic incentive to control the Hasa. The additional benefit to the peripheralization of the Hasa is the possible need for a buffer zone between the rival Edomite state in the south. Consequently, controlling the Hasa both economically and politically provided significant gain to the Moabites during the IA.

The assessment of the results within the framework of the Hasa Synthesis illustrate the risk minimizing, flexible subsistence systems of tribal groups in marginal landscapes of the Southwest Asia in general, in southern Levant specifically, where the fluid social dynamics contribute to the survival of people under stress –environmental or political. Under conditions without significant perturbations, tribal groups have the potential to develop social complexity. Through these almost cyclical practices (i.e., aggregation-dispersal, agropastoral-pastoral, competition-cooperation), tribal groups have been thriving on landscapes that are usually inhospitable to hierarchic social systems, and thus crafting a highly resilient social and economic relationship with the environment. This aspect of the Hasa settlement systems has been well documented by the new settlement concept.

Landscape Evolution and Human Impacts

The environmental conditions in the Hasa have been translated into several crucial variables and using a GIS script, the evolution of the landscape, without human factor, was modeled. The results suggest that Hasa is in general a stable landscape that has not been subjected to significant erosion with the exception of the main Hasa channel between As-Safi (i.e., the western terminus) and the central portion. As-Safi is the point where Hasa main channel carves deep gorges and drains into the Dead Sea. Through time, with aridity and possible changes in rainfall regime (i.e., more balanced and spread out pattern of Chalcolithic and EB I-III vs. slightly less rainfall in fewer events), erosion

changes scale and starts to deposit more sediment, especially during the EB IV (Table 22) while carving the main channel between As-Safi and central Hasa.

Human impacts in the Hasa have been argued in the context of another GIS modeling script that models land cover changes caused by extensive agropastoral land use. The results show that both agricultural and pastoral activities, regardless of site size, function, temporal association or location in the Hasa landscape, favor spreading of grasslands and open woodlands, which are beneficial for tribes as these lands are maintained continually and support dimorphic (i.e., agropastoral) social structure. These results also provide further support for the resiliency aspect of tribal organization and extensive subsistence systems in the marginal lands of the southern Jordan.

Hasa Synthesis in the Regional Context

The evaluation of the Hasa Synthesis in the regional context of the southern Levant is important to understand how much the Hasa is similar to and where it diverges from the culture history of the region. It has already been emphasized that the Chalcolithic in the southern Levant witnessed the establishment of mixed economy (i.e., farming, horticulture, and herding), which contributed to the emergence of large settlements for the first time (Levy 1995: Bourke 2001). The Hasa settlement record reflects signs of such economic organization with relatively lower –in comparison with the rest of the region– density of settlements, which focused mainly on pastoral production to support themselves (Figures 9, 14, 70, Table 5). The Hasa Synthesis views Chalcolithic as a transitional phase in the social evolutionary context of the Hasa –due to low settlement density (Figure 6)– into a more complex economic and social organization (compare Figures 9-10, 15-16 and 92a-93a), which was mainly a factor of wetter climatic conditions (Figure 57, Table 14) in such marginal landscapes. Hasa population remains heterarchic (i.e., no central/formal control over population, decisions made at the level of kins). The development of social complexity (i.e., social and settlement hierarchies), integration of pastoralism and agriculture into a more complex subsistence system (e.g. terrace agriculture, irrigation, long-distance exchange), emergence of cities and advance of some cities into polities in the Levant (e.g., the Karak plateau) support this perspective about the Chalcolithic period and its significance for the social, economic, and political transformations of the Early Bronze Age, as summarized by Bienkowski (1991) and Bourke (2001).

The Early Bronze changes in the social, economic and political landscape of the southern Levant are partially reflected in the settlement systems of the Hasa. The increase in settlement density (Figures 6 and 15), site type diversity (Figure 10), the variety of landforms utilized (Figures 40-43) take place under favorable climatic conditions (Figure 57 and Table 14). As proposed in the Hasa Synthesis, these changes reveal how the Chalcolithic kins decided for aggregation and establishment of a more complex, extensive economic organization (i.e., horizontal expansion across the landscape as shown in Figure 70) under certain climatic conditions. However, the initially low settlement density, scarcity and sporadic distribution of critical resources such as water, soil and timber –i.e. the marginal environment of the Hasa– put limits on the scale of social transformations and the autochthon development of the society and economy never reached the level of hierarchies (Figures 93a and 95). This agrees well with the general

lack of evidence for social complexity in the southern Levant, which never had sufficient resources or population density for such social evolution.

The climatic degradation, collapse of economically and politically complex social structure in the Levant -and elsewhere in the SW Asia- during the EB IV have been discussed and outlined by Bienkowski (1991), Dalfes, Kukla and Weiss (1998), Palumbo (2001), Nichols and Webber (2006), and Yoffee (2006). The climatic changes that have been argued to impact the first socially complex entities in the Levant are clearly visible in the paleoenvironmental data (Chapter 3) and from the climate data of the weather stations around the Hasa (Figures 54, 56-57 and table 14). As the major Early Bronze sites at environmentally more advantageous locations, such as Bab edh-Dhra near the Dead Sea suffer greatly from progressive aridity and its impacts on the subsistence (e.g., drop in yields, interruption of trade relations), the Hasa Synthesis predicts that the political, economic and social consequences of such events would be much larger in scale at marginal environments such as the Hasa. The Synthesis states that under reversal of climatically favorable conditions, the kins that benefited from living together at larger settlements and producing together for possible surplus would revert to kin-based, selfsufficient economic organization. Such changes are translated as significant drop in settlement density (Figures 6 and 16), site type diversity (Figure 11), and diversity of landforms (Figures 40-43). These changes are evident in the archaeological record of the southern Levant and the Hasa. Following this major transformation, the agropastoralist nature of the Early Bronze population is replaced by pastoralism (Table 5). Such significant change in the subsistence is visible in the multi-modality of elevation
distribution of settlements (Figure 70 and Table 16). The predictions of the Hasa Synthesis (i.e., group fission and abandonment) in relation with the social and economic transformations of this period is best illustrated by Figure 92b, which portrays the change in social organization as a factor of massive abandonment in the Hasa. The Hasa seems to follow the regional patterns in terms of social complexity, subsistence patterns and political organization. However, the drainage also creates its own dynamics in these areas. Unlike the rest of the SW Asia, the late Early Bronze collapse and abandonment in the Hasa had long-term social and economic impacts. Based on the settlement patterns, population density and other archaeological data, it is apparent that the abandonment continued until the end of the Late Bronze, for almost 1,200 years (for an overview of the Middle and Late Bronze culture history in the southern Levant, see Chapter 3, Bienkowski 1991, Ilan 1995, Bunimowitz 1995, Falconer 2001, and Strange 2001). Although the effects of natural and cultural formation processes, the bias in the recording of archaeological projects need to be acknowledged, it is also true that these processes have been active wadi-wide and the sample used here is still accurately representing the situation in the Hasa. Such long-term abandonment of the Hasa can only be explained in the relation to the environmentally marginal character of the wadi: except for the few pastoralist settlements in the high and lowlands of the Afra and Thamad drainages in the west Hasa, the settlement activity has been rare across the Hasa.

The Iron Age in the southern Levant represents the emergence of territorial states on either side of the Jordan Rift Valley (Bienkowski 1991 and 2001: Finkelstein 1995: Holladay 1995). Herr and Najjar (2001) provide a detailed summary of the Iron Age culture history. Following the emergence of major political and economic transformations in the southern Levant, the case of the Hasa, which is now between the states of Moab and Edom, is interesting as a drainage system, which remains lightly settled for over a millennia. The Hasa Synthesis suggests that this period is the second time in the early metal ages when the social and economic conditions in the area make denser population, co-habitation of kins and increased economic production possible. However, these transformations have a different root from the Early Bronze. The Hasa goes under peripheralization during the Iron Age (Figures 81-82, 85-87) and based on the unaffected population density and settlement hierarchies from the late Early Bronze abandonments in the region, the Moabite state seems to be the best candidate for being the core region of the Hasa. It is also feasible for the late Early Bronze inhabitants of the Hasa to seek refuge on the Karak plateau after drought sets in.

The Hasa Synthesis proposes that the Hasa becomes a periphery for mainly three reasons, which were mainly economic and political incentives for peripheralization of the Hasa: the need of the Moabites to complement their heavily agriculturalist subsistence system with a pastoralist element (i.e., the continued multi-modality of the elevation distribution of sites in Figure 70, which is also called vertical extensive economic organization), the attempt to control the Arabian caravan trade that crossed the Hasa around As-Safi (Figure 88) (Bienkowski 2001: Bienkowski and van der Steen 2001) and to secure the southern flank, which is the border with the Edomite state in the Buseira area –compare Figures 77 and 79– (Finkelstein 1992: Bienkowski 1990 and 2002). The Hasa Synthesis uses these incentives and peripheralization of the Hasa to explain the

different nature of the settlement (see Daviau and Chadwick 2007 for recent evidence of the Moabite presence in the Wadi Thamad of the west Hasa). The analysis of the Iron Age settlement data reveals how the presence of an external political factor, controlling the subsistence and trade of the Hasa brings population aggregation and such economic and political designs lead to the emergence of social hierarchies (Figures 93b and 94).

In terms of the emergence of social complexity, the Hasa is both similar to and different from the rest of the southern Levant. The Hasa is reflecting a regional pattern in how social complexity emerges: the hierarchic social organization is always tied to an external factor in the southern Levant. The first cities that emerged during the Middle Bronze Age were the colonies of the Middle Kingdom Egypt (Bienkowski 1991: 7-10). Later in the Iron Age, the emergence of the Israelite state in the coastal Levant brought reactive formations of state in the Transjordanian Plateau (i.e., Ammonite, Moabite, and Edomite states). However, the Hasa is also unique in the sense that the emergence of social complexity (i.e., hierarchies) appear very late in comparison with the archaeological record for the rest of the region. This can be attributed to the marginal landscape and scarcity of its critical (e.g., water) resources. The Hasa becomes integrated into the regional politics and economies (e.g., long-distance trade) when the major nodes in the political landscape (i.e., the Moabites) needed other -and diverse- resources that were economically feasible. That was when the Hasa settlement systems evolved (compare Figures 15 and 17).

Broader Impacts

This research contributes to archaeology in specific, however the broader impacts are directly related to interdisciplinary research of complex adaptive systems. Consequently, both the methodology and the results of this research will be useful to researchers with parallel interests.

The contributions to the archaeology of dry lands can be summarized as:

- Illustrating how tribal societies manage limited, sparsely distributed resources in marginal environments by developing risk-minimizing behaviors such as adjusting the composition of their subsistence patterns.
- 2) Interpreting abandonment and resettlement as part of such behaviors in which the aim is to break away from a social and economic system that has become less productive both economically and socially. Tribal alliances or competitions for resources are both valid tactics for the survival of kins/lineages on the marginal landscapes.
- 3) Revealing the diversity of human responses in the early metal ages to wide topographic and climatic differences within a drainage system, which emphasizes the resilient nature of tribal societies through flexible subsistence systems, which are inherently reflected in settlement systems and land use patterns in a region.

The broader impacts of my research apply to a new research area where scholars are interested in understanding complex systemic interrelationships among social systems and ecosystems. This has recently led to the emergence of the term 'human socioecosystems'. In this new approach, the aim is to understand how human adapt to certain environmental conditions, what the nature and extent of each relationship with the ecosystem is, and more importantly how intended and unintended consequences of these interactions play out in the long-term. The researchers are equally interested in conceptualizing the society as a dynamic system that changes as results of such interactions. For scholars with parallel interests, my research is more important for its methodology, since it combines data from wide variety of fields. The analyses of data from diverse sources are usually done with GIS, which is also capable of illustrating the results. Especially the use of MEDLAND scripts enables researchers to explore how processes bring change in dynamic and complex set of relationships. In that respect, my research on the early metal ages of the Hasa landscape, settlement systems, land use and landscape evolution is a new case study where the above dynamics are tested in the context of tribal societies.

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