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8 Conclusions:

The Impact of Climate Change on Settlement Behavior

The present study aims to assess the impact of climate variability on pre-Hispanic (1500 BCE–1532 CE) settlement behavior and general cultural development in the northern Río Grande de Nasca drainage (South Peru, 14.5°S). The study area is located in an arid environment comprising all altitudinal steps of the Andean west flank from the foothills starting at 300 m.a.s.l. up to the water divide at 4000–4500 m.a.s.l. It comprises the valleys of the Río Grande, Palpa, and Viscas rivers as well as the areas between. In this region, already slight absolute variations in climatic parameters have a significant impact on the availability of the resources crucial for human subsistence. This is especially true for precipitation which increases with altitude, and temperature which decreases with altitude. Both factors can cause reduction of agricultural production in the case of drought and frost. As a consequence, fluctuations of these climatic parameters have repeatedly been proposed to have either challenged or favored human subsistence and to have thereby triggered major cultural developments in the region.

By a diachronic analysis of settlement patterns, variations in population levels, political organization, intensity of conflicts, and land use were identified. Were these major changes in settlement behavior indeed caused by climate change? The results of the analysis of archaeological data were compared to a reconstruction of the paleo-climate based on published data from geomorphological and sediment studies in the study area itself and in remote regions. Since no published data is currently available that reflects changes in temperature patterns, paleo-climate reconstruction focuses on precipitation. During the last 3500 years, the climate around the town of Palpa (350 m.a.s.l.) shifted between hyper-arid and near semi-arid. Conditions in the highlands were always moister in relative terms, following a non-linear, altitude-dependent precipitation gradient. Rainfall in this area feeds the rivers that cross the desertic foothills, creating fertile valley oases.

During most epochs, cultural development at the foothills differed from that in the highland section (above approximately 2000 m.a.s.l.) of the study area, which is known as the *cabezas*. Marked differences in architectural traditions and settlement layout suggest that the inhabitants of both regions did not share the same culture or ethnicity, even though interaction between them was intense. Between the start of the Initial Period and the start of the Middle Paracas phase (1500–450 BCE), population density and social complexity were low and cultural development was smooth. Stylistically, after 800 BCE local traits were complemented by iconographic elements from the north associated with the Chavín and Cupisnique styles but a general change in settlement behavior and socio-political organization cannot be deduced from the archaeological record. No settlements of these phases are known from the *cabezas* so far. An important concentration of villages can be observed in the Collanco section of the upper Palpa valley. The apparent paucity of sites at the foothills may be explained by the covering or destruction of villages located at the valley floors due to intense agriculture in later phases.

Arguably during the late 5th century BCE, towards the end of the Middle Paracas phase, a process suddenly started which triggered profound changes in culture, demography, social structure, and political relations. It was characterized by a massive immigration of foreigners – probably originating from regions east of the water divide – into the *cabezas* section of the study area, a decrease of stylistic influences from the north (Cupisnique/Chavín), and a sharp increase in violent conflict. With regard to economy, the newcomers probably introduced camelid herding in the study area.

At the end of the Late Paracas phase and during the earlier part of the Initial Nasca phase (300–100 BCE) many *cabezas* settlements were abandoned and their inhabitants left the study area. At the same time, population density

at the foothills increased dramatically. Since settlement layout and architectural traditions were clearly different from those at the highlands, it is unlikely that the *cabezadas* population moved into the middle and lower valleys. It is more probable that groups from the northern South Coast valleys, especially from the Ica valley, immigrated into the Palpa region. At the same time, a stylistic influence known as Topará becomes evident. This style is believed to have originally developed in the Cañete, Chincha, and Pisco valleys, but little research has focused on this subject and a detailed style definition has not yet been presented. In the study area, Topará material does not occur in discrete contexts but is mixed with, or cannot be distinguished from, local wares. Apart from stylistic influences, new burial customs were introduced. Furthermore, settlement patterns suggest the emergence of a settlement hierarchy that indicates an increase of social complexity and the beginning of political integration on a local level.

Since the latter part of the Initial Nasca phase, starting around 100 BCE, the manifold and highly dynamic social, political, and demographic processes lead to the formation and consolidation of a new cultural tradition: Nasca. Burial customs and decorative styles become more uniform and political integration expanded. During the Early Nasca phase, settlement patterns support the assumption that a unified and drainage-wide polity existed whose capital was the great temple city of Cahuachi in the Nasca valley. Local centers, such as Los Molinos and Llipata in the study area, were probably subordinate to Cahuachi. The *cabezadas* were almost completely uninhabited while settlement density at the foothills remained high. Towards the end of the Early Nasca phase, around 300 CE, Nasca society experienced a sudden collapse, according to the definition proposed by Joseph Tainter (1988). Cahuachi and many related local centers were abandoned, the drainage-wide polity dissolved, and population decreased by at least a third.

Nasca society nevertheless seems to have reorganized soon and recovered rapidly. At the height of the Middle Nasca phase, around 400 CE, population levels may have reached almost those of the previous phase. The drainage-wide political integration was not restored, however, and power was concentrated in the hands of local lords, each controlling a valley or a larger valley section. Judging from their rich graves, at least some of them were astonishingly wealthy.

In addition to these foothills polities, the *cabezadas* were reoccupied at a scale comparable to the Middle and Late Paracas phases. The places chosen for settlements were often the same, and even the architecture shows some similarities. Again, the number of newly established settlements and the architectural differences to the ones at the foothills suggests immigration from outside the study area. The newly arrived *cabezadas* population may have catalyzed economic and cultural exchange with the Ayacucho region, which becomes especially evident in the archaeological record of the Late Nasca and Early Wari phases (450–750 CE) when first Huarpa and later Wari influence is recognizable in ceramic styles and architecture.¹⁵⁰

The Middle Nasca recovery was surprisingly short-lived, compared to earlier and later cultural developments. Towards the end of the phase, during the early 5th century CE, population levels went down again, both at the foothills and at the *cabezadas*. While the remaining highlanders concentrated in some already existing large settlements, in the lower sections of the study area the focus of settlement shifted to the middle and upper valleys and the most important centers were abandoned. This demographic and socio-political disruption was apparently not accompanied by a significant increase in conflict. During the following Late Nasca phase, new centers of power emerged at the foothills, e.g., Parasmarcha, but population levels stayed low. At the end of the phase, only the middle Río Grande valley was still settled relatively densely. At the *cabezadas*, only four settlements remained. At this time, mutual cultural influence between the Nasca and the Ayacucho regions intensified, and some immigrants from Ayacucho probably moved into the study area. During the early Middle Horizon (2nd half of the 7th century CE), the intense contact more and more turned into economic and political dependence of the Nasca region from the Wari heartland (Ayacucho).

Reconstructing the developments during the Middle Horizon (650–1000 CE) proved especially difficult because of the limited number of numeric dates and the paucity of diagnostic surface material. This period is characterized by the expansion of Wari presence in much of the

¹⁵⁰ Huarpa and Wari are the local cultures of the Ayacucho region during the Early Intermediate Period (100 BCE–650 CE) and the Middle Horizon (650–1000 CE), respectively.

Central Andes. Settlements at the foothills are mostly associated with sherds of early Middle Horizon styles, especially of the local variant called “Loro”. At many *cabezadas* settlements, in turn, surface material, but also typical architecture from the later Middle Horizon 2 phase was found. It has to be cautioned, however, that style chronologies for this period are not definitely fixed and may have to be redefined in the light of ongoing and future research. If the current chronology proves correct, two largely successive and only partly overlapping processes may have occurred in the study area. During the 8th century CE, the foothills may have been depopulated almost completely while probably not before the late 8th century, the Wari Empire established several administrative centers at the *cabezadas*. By that time, the entire Río Grande drainage should have been under formal Wari control, but direct administration and agricultural production seems to have focused on the *cabezadas*. Only shortly later, probably by the mid-9th century CE, virtually all known settlements were abandoned. Although it is likely that a few so far undetected small and simple hamlets continued to exist, population levels must have been extremely low for a long time (until the late 12th century).

Since the late 12th century CE, the study area was suddenly repopulated by large groups of immigrants. From written colonial sources it is known that the *cabezadas* were settled by the Rucanas and the foothills by the Nanasca. Both peoples established especially large and often fortified towns following their respective architectural traditions. Although often being of considerable size, these population centers show little architecture that could be interpreted as public, ceremonial, or administrative. Apparently, neither group was organized as a centralized polity. The larger settlements seem to have been largely autonomous but may have formed a confederacy in times of external threats. Settlement patterns clearly show an unsettled buffer zone between Rucanas and Nanasca, and fortifications and sling stone caches indicate frequent violent conflicts. It is nevertheless unlikely that these conflicts were predominantly interethnic in character, given the economic interdependence between foothills and *cabezadas* groups, but may rather reflect competition between direct neighbors belonging to the same people.

Population probably peaked during the 14th and 15th century CE. At this time, the study area reached its highest population density ever, including the present. As a consequence, almost

every possible patch of land was irrigated or terraced and brought under cultivation, including extremely steep slopes (more than 40°). Either around 1440 or 1470 CE, the Río Grande de Nasca drainage was incorporated peacefully into the Inca Empire. The Inca built administrative complexes in the foothill sections of each valley and added some structures to several existing Nanasca and Rucanas settlements, but their presence was nevertheless limited. They seem to have ruled indirectly through allied local elites. For most local commoners, daily life does not seem to have changed much, neither at the foothills nor at the *cabezadas*. During Inca rule, small-scale internal conflicts ceased and newly established settlements or added dwelling sectors were no longer fortified. In 1532, the Spanish invasion triggered the fall of the Inca Empire. According to the early Spanish chronicler Pedro Cieza de León, the Río Grande drainage was still densely populated at that time but suffered heavy population losses during the wars between different factions of the Spanish conquerors and their respective native allies (1537–1542 CE). Since he did not know the situation in the pre-Inca period, it is nevertheless possible that demographic development had already turned negative before the Spaniards arrived.

This reconstruction of cultural development based on archaeological data was compared to studies on paleo-climate to check for temporal correlations between significant changes in climate and major shifts in settlement patterns and population levels. The following paragraphs summarize the reconstruction of paleo-climatic developments drawing on studies by different research groups which cooperated with the Palpa Project during the past ten years (Eitel et al. 2005, Eitel & Mächtle 2009, Hesse & Baade 2007/2009, Mächtle 2007, Mächtle & Eitel 2009/2013, Mächtle et al. 2006/2010, Schitteck et al. 2012, Unkel & Kadereit et al. 2007).

Before 1000 BCE, evidence for loess erosion signals a lacking vegetation cover suggesting prevailing arid or even hyper-arid conditions at the foothills. At the same time the formation of first irrigated anthrosols in some sections of the valley floors indicate early irrigation agriculture in the river oasis. During the following centuries until at least 700 CE, the cultivated area was extended and probably irrigated without major interruptions. This would be evidence for the continuous availability of irrigation water in sufficient quantities, even though precipitation at the headwaters of the rivers had varied. Such variations cannot be deduced directly from local

geoarchives, so far, but are suggested by studies of remote archives. From 1000–650 BCE, conditions may have been near semi-arid, except for a short hyper-arid phase in the early 9th century BCE. Thereafter, climate was probably variable until 450 BCE. Starting then, more or less stable arid conditions probably prevailed for almost a thousand years, until 500 CE. Only in the early 3rd and the early 1st century BCE, average annual precipitation may have slightly decreased.

From 660–770 CE, several local geoarchives provide evidence for occasional flash flooding caused by rare torrential rainfalls. This phase of relative instability preceded a longer period of increased aridity, which lasted at least until 1250 CE. Remote archives suggest that it may have been interrupted by moister conditions during the 10th and early 11th century CE. Local evidence supporting this scenario has not been found. Both local and remote records testify to the prevalence of a stable and near semi-arid climate between the late 13th and the early 15th century. Since 1440 CE, however, precipitation seems to have become highly variable and climate tended to return towards hyper-aridity.

Conclusions concerning the impact of climate variability on settlement behavior and population levels can be drawn by juxtaposing the reconstructions for both these kinds of phenomena. Fig. 121, showing the developments in culture, population levels, and average annual precipitation on a time scale, illustrates the following statements.

If climate before 1000 BCE was indeed highly volatile and tended to hyper-aridity it is nevertheless unlikely that these unfavorable conditions caused serious problems for the inhabitants of the study area. In this early epoch, people were still few in number and would only have used a fraction of the potentially available agricultural resources. They would accordingly have remained unaffected by a reduction of these resources. After 1000 BCE, a favorable climate may have enabled the initial occupation of the Collanco area where rain-fed agriculture was practiced at an altitude as low as 1600 m.a.s.l. This would not have been possible under arid or even hyper-arid conditions. The return of a more variable climate from 650–450 BCE may therefore have caused a temporary abandonment of the area. Unfortunately, the resolution of the archaeological data does not suffice to indicate clearly whether this was actually the case.

Climate seems to have been arid and stable from 400–200 BCE and possibly even slightly

more favorable during the late 5th century BCE. This situation may have attracted the settlers who occupied the *cabezadas*. The abandonment of that area, in turn, does not correlate with significant changes in precipitation levels and, since the few remaining villages were located at relatively high altitudes, it is also unlikely that a substantial drop of temperatures threatened the local subsistence economy. The immigration into the foothills may at least indirectly be linked to the Topará phenomenon, which is not related in any recognizable way to climate change and should be regarded as a purely social and cultural development.

Throughout the late Initial and Early Nasca phases, geoarchives suggest sufficient and reliable precipitation in the study area. As a consequence, irrigation agriculture at the foothills should have been highly productive and surely supported the social, political, and cultural developments. Since comparable conditions had already prevailed during the preceding centuries, climate may nevertheless only be regarded as a supporting factor but not as a trigger. When the collapse at the end of Early Nasca occurred, precipitation patterns had not changed significantly. Accordingly, climatic fluctuations can be ruled out as an underlying cause for this phenomenon. Once again, socio-political events seem to have been the major driving forces.

The impact of climate change on the developments during the Middle and Late Nasca phases was probably low, if any at all. The decrease of population at the end of the Middle Nasca phase occurred at a time when precipitation probably increased. After a possible near hyper-arid phase during the early 6th century favorable conditions returned for another 100–150 years, but population in the northern Río Grande drainage did not recover. Accordingly, socio-political factors are more likely to have caused depopulation and the fading of the Nasca culture.

There is good reason to assume that the final abandonment of the foothills was related to a lack of irrigation water due to decreased precipitation at the headwaters, since the 8th century was probably one of the driest phases of the last four millennia. For the same reason, it is also likely that the majority of the Wari installations at the *cabezadas* were not established before the late 8th century, when conditions were slightly improving. It is nevertheless interesting to note that under the still near hyper-arid conditions (at the foothills), rain-fed agriculture and camelid herding at the *cabezadas* must have been attractive to the Wari, considering their invest-

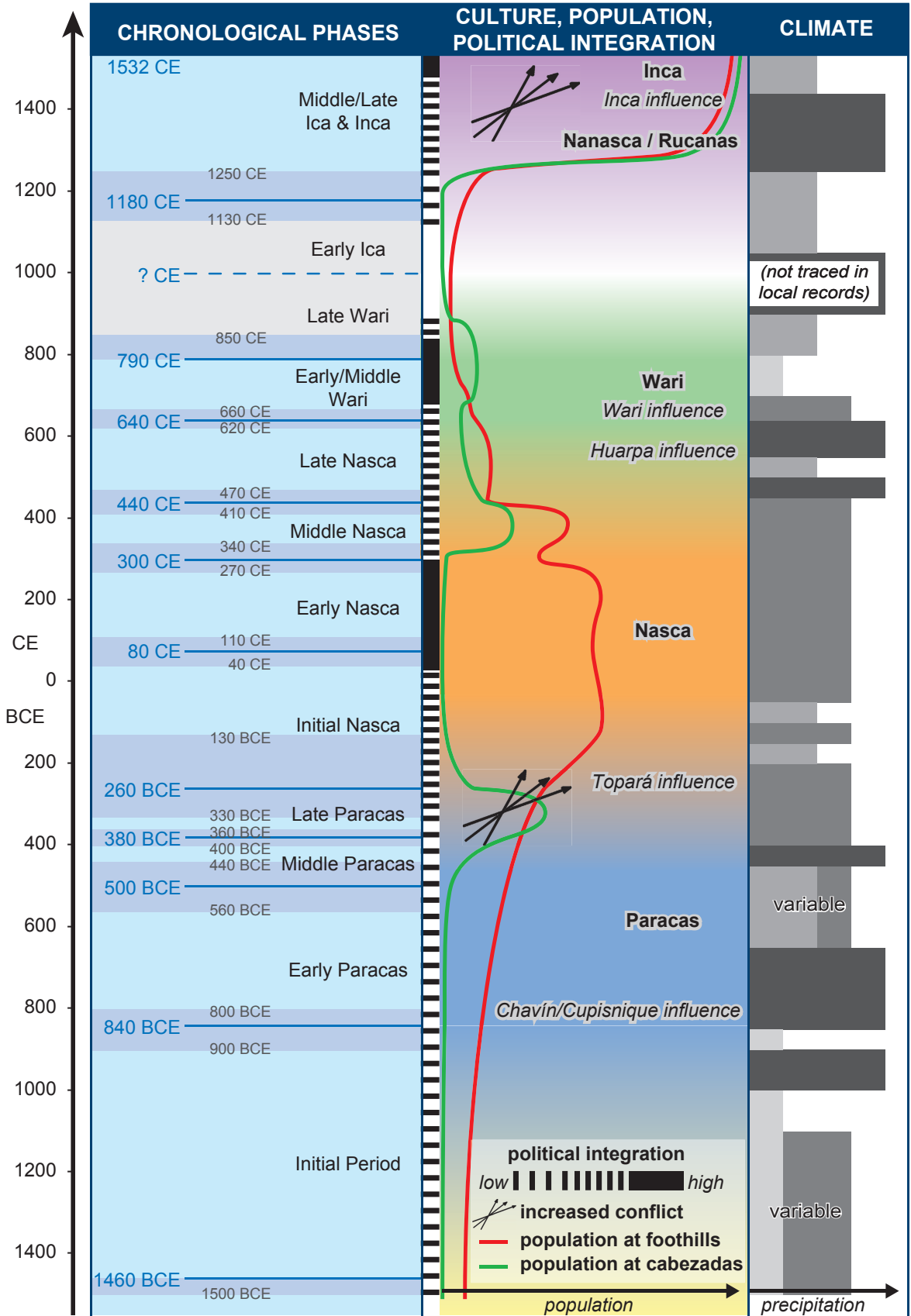


Fig. 121. Hypothetical comparative reconstruction of major cultural and climatic developments. Graphic: VS.

ment in building activity. The introduction of improved terrace systems may have been crucial for effective land use in a relatively dry area. If a return to favorable near semi-arid conditions from 900–1050 CE, as suggested by the records of several remote geoarchives, indeed occurred, it did not trigger resettlement. After approximately 1050 CE, climate became near hyper-arid again for at least another 200 years.

While the arrival of the first waves of Rucanas and Nanasca settlers probably fell within a phase of near hyper-arid conditions from 1050–1250 CE, the particularly favorable and near semi-arid climate during the following two centuries should have assured maximal agricultural productivity and allowed for very high population levels. Contrastingly, the return of near hyper-arid conditions since 1440 CE will have reduced food production. As a consequence an emigration wave would be expectable. Nonetheless, neither the settlement data nor early colonial written sources clearly indicate such a development. Since Inca-style or Inca-influenced ceramic sherds are rare in Nanasca and Rucanas settlements and local styles stayed in use more or less unchanged until the Spanish Conquest, it is almost impossible to distinguish settlements abandoned during the late 15th century from those which continued to be occupied. Accordingly, it is conceivable that settlement density indeed decreased. It would nevertheless be surprising that such an important and potentially traumatic event had already been completely forgotten a century later. But if it was well remembered, then it remains to be explained why the Spanish chroniclers did not make any remark about native oral traditions referring to a great famine.

In sum, regarding the entire cultural sequence from 1500 BCE–1532 CE, temporal correlations between significant changes in climate and major cultural developments are rare. In some cases the archaeological data in general and the settlement patterns in particular suggest high population levels and cultural heydays in phases of increased aridity while drastic population decline and the dissolution of polities can also be observed under comparatively favorable climatic conditions. Accordingly, a direct causal link between both kinds of phenomena is unlikely during most of the time frame relevant to this study.

It has to be cautioned, however, that the temporal resolution of most geoarchives studied by the paleo-climatologists is low and that major climatic events can often only be dated with a

margin of error exceeding ± 100 years. There are also uncertainties in interpreting the archaeological record. While ¹⁴C-dates are numerous and reliable, the samples are not equally representative for all cultural phases and for the entire study area. The relative chronology predominantly relying on the seriation of ceramic styles is also insufficient for certain periods, especially for the Late Intermediate Period. These potential sources of error hamper the reconstruction of past human-environmental relationships and may have led to a partial misinterpretation of either the archaeological or the climatological data, or both.

Only additional, high-resolution data can clarify whether correlations were actually stronger and more frequent than it has been concluded here. If the results of the present study were confirmed this would still not mean that climate had no impact at all. It certainly had, but its fluctuations only rarely jeopardized a society or triggered a cultural heyday. As long as climate did not turn hyper-arid, precipitation seems to have been sufficient to enable rain-fed terrace farming at the *cabezadas* and to irrigate the lower valley floors with the water of the rivers running from the highlands.

Full-blown hyper-aridity over a period of at least several decades probably only occurred during the later part of the Initial Period (11th and early 9th century BCE) and again during the Middle Horizon (8th century CE). Since in both cases population density had already been low before it is unlikely that the availability of water for agricultural production was reduced to a degree where major crop failures and widespread famine would have resulted. During all other phases, climate will still have had an impact in a way that especially favorable (stable arid or near semi-arid) conditions additionally supported cultural and socio-political developments or encouraged immigration while less favorable (variable and near hyper-arid) conditions may have exacerbated socio-political crises and stimulated emigration. Interaction with regions neighboring the study area nevertheless seems to have had the greater effect on population exchange, economy, politics and conflict, and general cultural development.

Outlook and Proposals for Future Research

The present study should be considered part of an extended research network. It profited very much from the pioneering works of other scholars directly involved in or associated with

the Palpa Project and will hopefully likewise be of help for current and forthcoming studies. The very large amount of archaeological data available allowed for a detailed analysis and an in-depth discussion of settlement patterns and general cultural development. Many resulting conclusions nevertheless remain tentative until data gaps are filled by future studies. This is especially true for the reconstruction of migration movements, which requires comparison with data from neighboring regions where archaeological studies are often either very limited or poorly published. In the study area itself, many detailed excavations have taken place so far, but still there is some imbalance regarding the diverse cultural phases and the geographic distribution. Namely, settlement sites dating to the Late Intermediate Period (LIP, 1000–1470 CE) have received comparatively little attention as have Early Intermediate Period (100 BCE–650 CE) settlements at the *cabezadas*.

The LIP is a key period because it offers the greatest potential for multi-disciplinary research. The archaeological record is the best preserved but surprisingly also the least investigated. Additionally, several colonial documents contain information that would be impossible to gather by excavation alone, for example, the names of important persons and places and the relations between them. The results of Mareike Mölders' current PhD project can be expected to enable new insights gained from the analysis of ethnohistoric sources. Besides cultural development, the evidence for climate change also seems to be more detailed and less ambiguous for the last 500 years before the Spanish Conquest. Accordingly, the LIP clearly is the period for which human-environmental relationships can be reconstructed with the greatest confidence and the highest level of detail. If these centuries were well understood, it would probably also be easier to interpret the much more fragmentary record of earlier periods.

This is also true for the transitions from the Paracas to the Nasca culture (300 BCE–100 CE), which marks an especially dynamic and far-reaching cultural change. For this reason, the respective period is the current research focus of the Palpa Project. Ceramic analyses in the scope of the PhD projects of Heike Otten and Daniela Östreich, the M.A. study on super-regional comparisons of architectural features by Emilia Schmidt, and the PhD research of Christian Mader on economy will help to clarify the relations between groups settling at the coast and at the foothills with those dwell-

ing at the *cabezadas*. They may also shed light on far-distance relations. The initial settlement of the study area and the concomitant cultural and environmental circumstances constitute the prelude for the developments discussed in this study and are being investigated in the scope of the PhD project of Hermann Gorbahn, who takes the archaic settlement of Pernil Alto as an example. There still is a data gap between the latest occupation of this site (around 3000 BCE) and the earliest one of the Initial Period (1500–840 BCE) which will hopefully be filled soon by new research.

At all times, agricultural production was very important, but economic exchange with distant regions may have focused on rare and valuable luxury goods rather than on food. This aspect has not been treated prominently in the present study, but since it is also related to stylistic and other cultural influences, it surely deserves attention. Mining has been practiced in the study area for millennia and metals may have been an important trade good. The exploitation of mineral pigments for the painting and dyeing of vessels and textiles was also practiced. Pre-Hispanic mining and quarrying in the study area and in neighboring regions is the subject of a current PhD project of Benedikt Gräffingholt that will provide new insights into this complex matter.

The reconstruction of paleo-climate will also need refinement, especially regarding the amplitude of major changes and the numeric age control of the periods prior to 600 CE. More local high-resolution data is desirable. Furthermore, the impact of temperature fluctuations on the upper limits of rain-fed *cabezadas* agriculture deserves to be investigated in detail. The ongoing analysis of drill cores from the Atocata cushion peatland by Karsten Schitteck and Markus Forbriger from Cologne University may soon shed new light on this important issue.

An especially interesting and promising field of research is agricultural terraces. If it proved possible to reliably date both the time of initial construction and the periods of use and re-use, terraces would be ideal markers for shifts of the lower boundaries of rain-fed farming. There are many terraces in marginal areas, especially in some larger quebradas such as the Quebrada Camajayoc, which are well preserved and largely untouched by recent cultivation. These would be an ideal starting point for a new project focusing on pre-Hispanic land use and its potential as a proxy for precipitation development. Likewise, *puna* terraces may indicate the periods during which the minimal temperatures during the

growing season were generally above 0°C even at altitudes exceeding 4000 m.a.s.l. Additionally, terraces may contain information on the state of technology (irrigation, drainage, moisture management, use of fertilizers). The ongoing PhD projects of Fernando Leceta on agricultural soils and of Pablo Jimenez on early water manage-

ment will be pioneering studies in this field for the study area and beyond.

Exciting new results from all the mentioned studies will be available soon. Since these will surely boost our understanding of culture and nature in the pre-Hispanic era, I look forward to comparing them to the conclusions of this thesis.