Introduction

This paper examines and interprets historical hydrological landscape change in Lombok, Indonesia from the 1894 time period to the present. Historical methods are used to interpret the physical, ecological, social, and cultural conditions of the agricultural landscape in Lombok (Cronon 1983; Meinig 1979).

This paper begins by examining Sasak ethnic identity in relationship to religious features on the landscape. Mosque number and pilgrimages to Mecca are examined in a landscape context. Toponymy is used as a method to analyze place names on maps particularly for springs, mountains, and villages. Springs play a prominent role in Lombok agriculture, village life, spirituality, and culture. Springs are examined along with protected forest groves. Lombok is an island with a high population density. There has been significant forest and wetland ecological change in Lombok. Forest and riparian change are examined in relationship to rice agriculture and historic buffer zones. Cattle grazing is reviewed to understand the impact on forests, accumulation of savings, and the accompanying introductions of highly intensive agroforestry practices and their influence on the hydrological landscape. In addition to toponymy, other methods used in this study include Geographic Information systems (GIS) analysis of a Nusa Tenggara province data set. Extrapolations have been made to approximate mosque and pilgrim numbers for a specific time period. Historical and contemporary images have been compared to determine degree of landscape change over time. This paper has not gone into the complex land tenure patterns that are a key component of any landscape transformation but will be a part of ongoing research.

This paper utilizes resilience theory to understand the socio-economic system of Lombok from the time frame of 1894 onward. An attempt has been made to define the characteristics of resilience in Lombok including identifying key adaptations as well as formulating a timeline for landscape change.
Background

The name Lombok was probably coined in the 16th century by Portuguese navigators who visited the island (1980). The definition of Lombok in the Indonesian language is “pepper,” but the terms Selaparang and Tanah Sasak are two original names for this island. Selaparang is a proud reference to the 16th century Sasak aristocracy in East Lombok while Tanah Sasak literally refers to the “earth of the Sasak,” in the Sasak language (VanDerKraan 1980).

Lombok is noted in the tourism literature as the “land of a thousand mosques.” In fact, Lombok is now the land of over 2500 mosques and these structures offer a profound glimpse of religiosity on the countryside. In Ampenan, Lombok there is a government banner that hangs at a key intersection advancing the Lombok people as “maju dan religious” (progressive and religious) (Klock 2007). The indication is clear, that religion and progressive thinking can co-exist among the people of Lombok. The landscape in Lombok is full of contrasts which create interpretation challenges for the researcher. As an example, figure 1 below portrays a Balinese Hindu temple and Islamic mosque in Cakranegara, Lombok. The image might invoke the following question; is there harmony or competition among religions as represented by proximity of religious structures on the landscape? Herein lays the test for landscape interpretation researchers. That challenge involves finding the correct social and environmental context for the image, map, or other period piece.
Viewing Lombok island by air, a visitor might observe some of the numerous mosques, and over 200 Hindu temples, that dot the landscape throughout 324 villages and larger cities (BadanPusatStatistic 2005). Lombok has three distinct physiographic areas as noted by Fisher (1999). These areas include the large Rinjani volcano complex which dominates the north; southern Lombok, composed of uplifted limestone and hilly topography; while the central plain of approximately 25 km entertains the greatest population density and constitutes one of the most intensive rice production areas in Indonesia. Lombok is divided up into three catchments and approximately 32 sub-basins for administration purposes. There are 119 significant spring sources noted by government agencies in Lombok (Suratman 2006). These spring sources are the “life
source” of the island and contribute the majority of drinking water and a significant proportion of irrigation water. 33 rivers are found in Lombok with 90 percent of these waters originating from the Rinjani Massif (Monk 1997). Drainage patterns occur in a radial pattern around Mt. Rinjani and historically, many of these rivers have been diverted or dammed for purposes of irrigation.

The Lombok human population has never been a static situation. Lombok’s central fertile plain today houses 60% of the island’s 2.9 million population and since 1971; the island population has grown by 1.8 million people. The island population in 1846 was estimated to be 405,000 according to Leeman (1989) who cites Zollinger’s document of 1851. By 1900 the population was estimated to be 530,000 and by 1920 it reached 617,000 according to Dutch census. In 1930, the Lombok population reached 701,000. Public health improved with the removal of swamps in Ampenan, Lubuhan Haji, and Pamenang according to Dutch records at that time (Leeman 1989).

Lombok is a Lesser Sunda island positioned at 8 degrees south of the equator and with a southerly half that straddles the climatic and biological shift called the Wallace line (Figure 2 below). In particular, the eastern and central areas of Lombok have been well-studied for the effect of drought and famine from irregular rainfall and a more recent historic over-concentration of people.
Scattered across an island that bears 60 km. by 80 km. at its widest point, is an agricultural society that has a remarkable number of historic hydrologic features. The Sasak, the indigenous people, practiced communal forms of resource management for centuries. The Balinese conquered and colonized Lombok and implemented the subak (termed irrigation associations, or irrigation societies. Geertz points out that subak are much more than irrigation societies (Geertz 1980). Rather, these bodies are agricultural planning units, independent legal institutions, and distinct religious communities.
The impact of the Balinese subak are seen predominantly in West and Central Lombok and more so among the Balinese, and less frequently elsewhere among the Moslem Sasak. The structure and viability of the subak in Lombok today are different than those found in Bali.

The Dutch takeover of Lombok in 1895 increased the wet-rice irrigation with an extensive increase in irrigation infrastructure to drier parts of the island but in so doing also imposed higher taxes on rice and stricter requirements for corvee’ labor. Both Balinese and Dutch periods caused a significant erosion of the Central Lombok forests through assorted policies that allowed for alienation of land parcels and expansion of rice lands.

The area of West Lombok is endowed with fertile soils and abundant irrigation water. In contrast, the area of south and Central Lombok has been described as a lahan kritis or critical lands due to the pronounced variability in climate. The critical area lies in the two kabupaten (districts) of Central and East Lombok. This area of Lombok has been depicted as experiencing famine due to a variety of separate conditions such as: drought, unequal land distribution, excessive number of sharecroppers, shortage of water, low soil fertility, cultivation of unsuitable crops, lack of fertilizers, adherence to traditional methods of farming, inflation, and limited access to credit and land tenure (Brennan 1984; Madconald 1983).

**Human Adaptation Background**

One of the goals of this paper is to view the manifestation of adaptation on the hydrologic landscape in Lombok. The means by which villages adapt and survive change has been the subject of a rich body of research on peasant moral economies (Scott 1976; Geertz 1963; Netting 1993). Scott mentions that low crop yields, low
incomes, and extraction by elites can have a huge impact on peasant life in Southeast Asia (1976). In most areas of Southeast Asia, the exposure to risk from commercial farming is high. In such locales, Scott suggests that man-made famines may occur. Through his work, *Agricultural Involution* (1963), Geertz studied rice and swidden agriculture in Indonesia, with a particular emphasis on peasant farmer survival, and land tenure under the breakdown of kinship and traditional self-help networks. Adaptation to environmental change is an adjustment in ecological, economic or social systems to observed or expected environmental stimuli. Evaluations of adaptive capacity measure levels of risk before and after adjustments have taken place. Adaptation under a resilience framework is different and is defined by Nelson et al. (2007) as “the decision-making process and the set of actions undertaken to maintain the capacity to deal with future change or perturbations to a social-ecological system without undergoing significant changes in function, structural identity or feedbacks of that system...”. The ability to adapt is based on three fundamental characteristics key to the ecological resilience school of thought. These are: 1) the degree to which the system is vulnerable to change while still maintaining function and structure, 2) the degree of self-organization and, 3) the capacity for learning (Nelson et al. (2007). Adaptive capacity describes the preconditions for a system to be able to adapt to disturbances. A lack of adaptive capacity, for example, can lead to a collapse of a system due to the inability to mobilize adaptive capacity. Monk concludes in his ecological work that the hydrological water balance is a key limiting factor for flora, fauna, and human populations on small islands such as Lombok (Monk 1997).
Methodology

1. Geographic Information Systems
   From September 2007 to April 2008, the author was involved in a Fulbright fellowship that allowed for a study of agricultural water management in Lombok, Indonesia. GIS data acquired during that time from the non-government organization Participatory Action Research, Rinjani (PAR) allowed for the interpretation of select aspects of the hydrologic landscape of Lombok. In particular, there were twelve shape files that proved useful in the analysis of the Lombok hydrology. Several maps made from this data set are included in this paper. In the desa (village) shape file, there were 666 identified units of study (villages) and 222 attributes. The attributes in this shape file covered the economic, health, cropland, springs, and numerous other data that are found throughout Nusa Tenggara province. The province contains seven administrative regions (kabupaten) composed of 59 districts (kecamatan) and 666 villages (desa) across four major islands.

There were several challenges that arose from the GIS data set. The first included a translation of specific Bahasa Indonesia language agricultural acronyms that were not readily identifiable in the shape files. The second concern involved finding the appropriate projection and datum for raster data conversion from older Dutch maps (1895 to the 1930s). Dutch maps and early records are written in the Dutch language. The GIS data set from the PAR-Rinjani is rich and the author was especially fortunate to obtain it.1 The full usefulness of this data set will take some time to fully analyze.

1 The author would like to thank the following groups and individuals who were helpful in providing information: PAR Rinjani, the Transform Organization and its director Pak Markum, the Pusat Studi Pembangunan NTB and Pak Burhanuddin, The Konsepsi Organization and Pak Humaidy, World Wildlife Fund NTB, the faculty and administrators at the University of Mataram, the PSSS institute and its staff on
2. *Toponymical Methods*
A grid was laid out on maps to aid in the identification and counting of specific place names. The following general place names were counted on four maps and one GIS data set: *gunung* (mountain), *bato, batu, batoe* (rock, stone), and *aik, air* (water). The names *Gunung Pengsong*, and *Gunung Hadji* were also reviewed for frequency of citing. 1897, 1908, and 1926 Dutch Topographic maps were examined with scales ranging from 1:25,000 to 1:200,000 (Government 1908, 1926-1931). One tourist map at a scale of 1:200,000 was used. The final source of information came from attribute files of the PAR GIS data set that were sorted by ascending alphabet and identified for desa (village) and mata air (springs).

3. *Mosque and Hajj Calculations*
Mosque presence was counted from Dutch topographic maps for the period of 1926-1931. Only West and Central Lombok mosques were counted on these early maps. Mosque numbers for East Lombok were extrapolated based on population at the time. Please see appendix 2. Similarly, pilgrimage visits to Mecca were determined from government reports, published documents (BadanPusatStatistic 2006; Daroesman 1976) and extrapolations (also shown in Appendix 2).

4. *Interpretation of Dutch Period Maps and Images*
Dutch period maps reveal abundant information about Dutch plans for the island, especially toward the late 1920s and early 1930s. The Netherlands Indies colonial government used Lombok as a source of revenue from the tax and trade of rice. Rice fields are identified across West and Central Lombok. Other useful information were religious structures (temples, mosques), graveyards, military installations, waterworks,
and tree crops. Images from the Royal Netherlands Institute of Southeast Asian and Caribbean Studies were purchased for the purposes of this research (Studies; RoyalNetherlandsInstitute 2007).

**Sasak Identity and Its Impact on the Landscape**

It is not the intention of this paper to examine the religion of Islam in ways other than a geographical spatial perspective on watersheds and agricultural water. This spatial analysis reviews two statistics; mosque number over time and pilgrim journeys to Mecca over a period of time. Indonesia as a whole is a melting pot of religions and ethnicities. The success of religious integration and religious harmony over the last 45 years in Indonesia is noted by Steenbrink (1993). With respect to the influence on the hydrologic landscape, the dynamic question here considers what are the forces driving the growth of orthodox Islam in Lombok. In Lombok, Sasak identity is closed associated with being Moslem as noted by Cederroth (1996) who elaborates:

*The political situation also contributed to the spread of orthodox Islam. When Lombok was conquered by the Dutch, after heavy fighting, in 1894, the island had already experienced almost two centuries of Balinese rule. Under the Balinese rajahs, it was above all the Sasak elite who had experienced oppression and had been frustrated in their political ambitions, but during the Dutch period the common people were also put under pressure, above all through heavy economic exploitation. In this situation, Islam was readily accepted by many Sasak as a marker of identity.*

In 1976, Daroesman (1976) articulates that Islam is a unifying force in Lombok society and the “tuan guru” has a large influence on the success of development and other activities. In 1974, she mentions that 1,040 people in an otherwise impoverished province made the pilgrimage or hajj (Daroesman 1976). The designation orang Islam and orang
Hindu are used today to define Moslems and Hindus in Lombok society (Gerdin 1982).

Gerdin mentions the following:

> Probably resentment of ritually expressed political inequality was one reason for the spread of orthodox Islam in Lombok. Lombok is the one Indonesian island with the highest proportion of people undertaking the pilgrimage to Mekkah. All pilgrims are orthodox Moslems, while syncretist Moslems look to the traditions of noble court rituals rather than turn to Mekkah. One might say that for many an orthodox Moslem in Lombok, one type of exemplary centre......namely the Balinese or Sasak court, has been replaced with an exemplary center of another kind: Mekkah (pg. 53).

Hunter mentions that the Sasak people in East Lombok are more likely to turn to religion, when times become more difficult. The reasons for this are unclear but may be related to interpretations of identity, past repression, and growing empowerment. Hunter further describes mosque building and renovation as ubiquitous in Lombok. “Traveling along the main road from west to east, one can see mosques being renovated or built in many of the villages” (Hunter 2004). Klock in 2006 and 2007 also noted the trend in mosque reconstruction in towns from the provincial capital of Mataram to the city of Praya. Harnish alludes that an assortment of forces (government religion offices, religious organizations, tuan hadji (religious leaders that have made the pilgrimage to Mecca, similar to tuan guru) and others are “compelling Sasak to act like Muslims and Balinese to act like Hindus…” (2005). In 2003 Hunter (2004) noted the growth to six Islamic organizations in Elah village, East Lombok since the end of the New Order (Suharto regime) from a previous number of three in the early 1990s.

Related to mosque construction is the pilgrimage to Mecca. A person who has made the trip is called a hadji (hajji) tuan guru or tuan hadji, an honor that bestows much respect from the community. Leeman (1989) explains that those who have fulfilled their
obligation to make a pilgrimage to Arabia, may as ‘tuan guru’ gather pupils around them. The resources to make such a trip are a subject of interest for this spatial study. Judd (1980) discusses the social dynamics of thrift and profit-making for the pilgrimage in Iaq Iqu Lombok. Judd notes that landlords and wealthy individuals have stopped partaking in most traditional Sasak ritual feasts, but instead save their money and goods for the pilgrimage. While adat emphasizes social responsibilities related to communal living; Islam orients individuals to the individualism and the ideal of simple living to save money to make the trip to Mecca. This “saving” of resources for journeys to the Mecca by village leaders can have a significant impact on village life in Lombok. This possible decline in one key patron-client safety net at the village level deserves further study, especially in highly impoverished parts of Lombok. Leeman comments that increasing Islamic piousness correlates to increasing market involvement of village economies from around the year 1900. Leeman further notes that in the Central Plain of Lombok, Islamization does not seem to oppose the accumulation of personal wealth. He notes that personal savings finance pilgrimages to Mecca but that the high cost of fulfilling the fifth pillar of Islam² (hajj) can involve land transactions as well as pelais. A pelais is a share-cropping contract where the share-cropper provides money in advance for the right of cultivation.

**Mosque and Hajj Numbers**

The mosque growth rate on Lombok plays a role in landscape modification. Mosque placement and construction are related to the population that can support the

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² The Five Pillars of Islam are: 1. Affirmation of Allah as the one and only God and Mohammed as his prophet. 2. The execution of prayer five times a day 3. The observance of the time of fasting in the month of Ramadan. 4Pilgrimage to Mecca a the height of celebrations, according to the health and financial situation of the believer. 5. The donation of alms. (Leeman 1989)
institution. Water is needed at the entrance of a mosque for bathing to ensure ritual purity. In Lombok, this source can come from a well, spring, or piped water. The challenge in this research has been to obtain a reasonably accurate figure for mosques for the years 1930, 1975 and 2005. Table 1. and 2 provide some approximate mosque and hajji numbers and estimates for the years 1930, 1975, and 2005. These counts and extrapolations are shown in appendix 2.

Table 1. Mosque Count

<table>
<thead>
<tr>
<th>Year</th>
<th>Mosque Count</th>
<th>Source</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>Est. 171*, and 574**</td>
<td>D. Topo 1926-1931</td>
<td>Hand count, extrapolation</td>
</tr>
<tr>
<td>1974-75</td>
<td>Est. 1437***</td>
<td></td>
<td>Extrapolation</td>
</tr>
<tr>
<td>2005</td>
<td>2522</td>
<td>Badan Pusat St.2005</td>
<td>Govt. statistics</td>
</tr>
</tbody>
</table>

Table 2. Haji Count

<table>
<thead>
<tr>
<th>Year</th>
<th>Pilgrim Count</th>
<th>Source</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>426</td>
<td>****</td>
<td>Extrapolation</td>
</tr>
<tr>
<td>1974-75</td>
<td>1040 (province-wide)</td>
<td>(Daroesman 1976)</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>2072</td>
<td>Badan Pusat St.2005</td>
<td>Govt. statistics</td>
</tr>
</tbody>
</table>

From Table 2. the number of mosques in Lombok for 2005 was 2522. In 1974, the estimate was 1437 and for 1930 two methods were used to determine mosque number. 1:25,000 scale topographic maps from the Dutch colonial period were analyzed for the time period from 1926 to 1931 (Government 1926-1931). From these maps, 171 mosques were counted for West, Central, and East Lombok. The mosque numbers reveal an increase of anywhere from 1900 to 2200 mosques increase over a 75 year period from 1930 to 2005. Appendix 1 highlights the methods and challenges used in determining mosque numbers.
Similarly, a reasonably accurate count for pilgrims is noted at 2072 in 2005 (BadanPusatStatistic 2006), and at 1040 (province-wide) for the year 1974 (Daroesman 1976). A less reliable statistic of 426 hajji was calculated for 1930 (Appendix 1).

**Ethnic Identity and the Results of Place Name Survey**

Defining ethnicity is important in Lombok (Harnish 2005). A place name with subak, kliang, pura, or Gunung Pengsong might involve a village with a large Balinese Hindu population. A place name with Labuhan Hadji, Aik Bukaq, Berugag, and Lumbung, or Selaparang International Airport would have a strong Sasak identification. Table 3. below notes that 4.6% of the villages in Lombok have the place name aik (meaning water) in the Periplus map. The PAR Rinjani GIS data set provided 8 spring place names utilizing the term aik that resulted in 8.4% of the spring number total (Prayitno 2005).

### Table 3. Lombok Place Names

<table>
<thead>
<tr>
<th>Map Name*</th>
<th>Scale</th>
<th>Gunung (all place names)</th>
<th>Batu/Batoe (all place names)</th>
<th>Aik/Air (all place names)</th>
<th>Aik % of Total</th>
<th>Gunung Pengsong -G.Hadji</th>
</tr>
</thead>
<tbody>
<tr>
<td>1897 D. Topo 1:200,000 scale</td>
<td>1:200,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>G.Pengsong -yes G.Hadji -no</td>
</tr>
<tr>
<td>D. Topo 1908</td>
<td>1:200,000</td>
<td>29</td>
<td>16</td>
<td>6 village place names</td>
<td></td>
<td>G.Pengsong -no G.Hadji -no</td>
</tr>
<tr>
<td>D. Topo 1926(Government 1926-1931)</td>
<td>1:25:000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>G.Pengsong -yes G.Hadji -yes</td>
</tr>
<tr>
<td>Periplus Tourist Travel Map: Lombok and Sumbawa</td>
<td>1:200,000</td>
<td>62</td>
<td>49</td>
<td>14 village place names</td>
<td>Approx. 4.6% of villages in Lombok have word aik in name</td>
<td>G.Pengsong -yes G.Hadji -no</td>
</tr>
</tbody>
</table>
**GIS Database 2005 (PAR Rinjani) Village attribute file**

<table>
<thead>
<tr>
<th>Desa—</th>
<th>Mata Air—</th>
<th>2</th>
<th>14</th>
<th>5 village place names</th>
<th>Approx. 1.6% of the villages use the word aik in name</th>
<th>G.Pengsong yes</th>
<th>G.Hadji -no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>8 spring place names</td>
<td>Approx. 8.4% of the springs use the word aik in name</td>
<td></td>
</tr>
</tbody>
</table>

*Sources:*
- D.topo = Dutch topographic (Batavia 1908) KIT Royal Tropical Institute, Amsterdam(Government 1908)
- D.topo = Dutch topographic (Batavia 1926) KIT Royal Tropical Institute, Amsterdam(Government 1908)
- (Government 1926-1931)

**Gunung Pengsong and Gunung Hadji**

Toponymy is further used to analyze religious context and influence. *Gunung Pengsong* is a historic mountain in Balinese folklore and conceived as the arrival site of the first Balinese on the island most likely in the late 1600s. In the historical work by Hagerdal (Hagerdal 2001), there is an English translation from Gerdin’s oral history work on Lombok entitled “Babat Lombok Banjar Getas.” In this story, *Gunung Pengsong* is identified as a key reference point. Three photos are provided of the mountain here.

Figure 3 shows the landscape looking from the top of the Balinese Hindu sanctuary on *Gunung Pengsong* taken by the author in November of 2006. Figure 4 shows a perspective from the 1930’s. Neither scene is identical but both scenes depict dry deciduous tree vegetation indicative of a monsoon forest type during the dry season. In
From an 1897 Dutch topographic map the mountain name *Gunung Pengsong* is present (Figure 6). From the 1926 Dutch topographic map (Government 1926-1931) *Gunung Pengsong* is present as is a mountain next to it called *Gunung Hadji* (beside Sengkongok village) (Figure 7). *Gunung Hadji* is not found in other maps although there are no other maps at the 1:25000 scale examined for that location. *Gunung Pengsong* is found in the 1897 1:200,000 scale topographic map and on tourist maps. On the 1:25,000,
1926 Dutch topographic map used for this study, a 2 kilometer radius was drawn around *Gunung Pengsong* mountain. From this radius of the 1926 map, there were 12 mosques counted. The question raised in this case is as follows: was the naming *Gunung Hadji* a sign of political change with growing Sasak influence on the landscape and declining Balinese Hindu impact? Certainly, the Dutch defeat of the Balinese Hindu in 1894 resulted in a decline in the fortunes of the Balinese in West Lombok. Growing Sasak identity in the 1920’s and resentment of Dutch rule was also evident (Gerdin 1982; Cederroth 1996). Other *hadji* (also spelled *hajji*) place names exist in Lombok. *Labuhan Haji* is notably famous city on the east coast of Lombok and known for the start of pilgrimages to Mecca and as a renowned older port visited by Arab traders.

**Figure 6. 1897 Dutch Topographic Maps of Gunung Pengsong**
**Protected Springs and Forest Groves**

There are over 100 critical springs identified by the provincial government that have significant spiritual, cultural, and economic importance in Lombok. Most of these springs have been prioritized for use as either agricultural or drinking water and have been altered in some manner by concrete enclosures and pipes (Figure 8).

**Figure 8. Concrete Spring Box with Spring now Controlled by PDAM Utility and Diverted to City of Praya (photo by John Klock, Nov. 2006)**
Figure 9. shows the location and flow rate of major springs and their relationship to the critical dry lands. The Hindu temples in West Lombok are often found in springs, protected forests, and scenic outcrops. *Pura Lingsar* is one such temple with a prolific spring in West Lombok. Each year, a ritual attended by Hindu and Muslim alike, is commemorated by thousands of people to express gratitude to ancestors and give thanks for a spring that irrigates hundreds of farms throughout West and Central Lombok (Nugraha 2006). In Lombok there are numerous traditions of protecting forests and planting trees Muslim and Hindu alike. In the village of *Aik Bukaq*, near the site of Aik Bone spring, there is a protected forest (please see Figure 10.).
Figure 9. Location and flow rate of major springs (Map created by John Klock, March, 2008)
Remnant forest groves are still seen in villages around Lombok with protected springs including the forest surrounding Aik Bone PDAM. The people living in Aik Bukaq note that mahoni (Sweitenia macrophylla), and jelateng (Ficus spp.) are believed to hold water and are thus protected species. People are prohibited from cutting trees, around these springs and if caught, brought before a local court.

Monk et al. (1997) notes that small sacred groves are still found in Lombok ranging from two to five hectares. These remnants provide a glimpse of the monsoon forest of Central Lombok that was ubiquitous 100 years ago. Often these forests are found in relationship to Waktu Telu groups which number a few thousand people on the island. Other small groves are found at Hindu temple sites while still others are protected communally through traditional laws (adat). Van der Kraan (1980) has discussed the private hunting grounds of the Balinese Raja Ratu Agung2 Ngurah who was in power from 1872 to 1894. There were at a minimum of 32 grounds in West and East Lombok in

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3 Waktu Telu is a syncretism of Sasak adat, Hindu-Balinese beliefs from Java and Bali and Islam. It is not recognized by Orthodox Moslims as a legitimate faith.
forested areas guarded by a royal police force. These hunting grounds were taken over by the Dutch Indies government in 1895.

**Central Lombok Forest Change**

Analysis of the landscape from 1894 is important to comprehend the larger framework of ecological and social change in Central Lombok regency. Central Lombok has diverse forest types ranging from high altitude semi-evergreen forests to lower elevation moist deciduous monsoon forests, to a coastal dry deciduous monsoon type. Tropical moist deciduous forests receive over 1500 mm of rainfall a year and have four to six dry months per year and this type is more commonly found inside Rinjani National Park. Tropical dry deciduous forests receive less than 1500 mm and have more than six dry months per year. Appendix 2 provides a comparison of historic vegetation and degradation stage.

Today in Lombok, old growth forests are difficult to find in the lowlands. The removal of forest cover in Central Lombok has been noted by Monk et al. (1997). A chronology of ecological disturbance is found in Appendix 3 with footnotes. Particularly at 100 to 400 meters in elevation there are only gallery monsoon forests seen in ravines, as well as grasslands, and scrublands. Monsoon forest are highly vulnerable forest formations and easily lost. As monsoon forest is cleared it can become *belukar* (deciduous scrubland) (Monk 1997). Monk estimates that 8.17% of Lombok is covered in *belukar* mostly in the southwest. 100 years ago, a dry deciduous forest was ubiquitous but converted by either shifting cultivation, grassland burning, or grazing.

*Belukar* or scrublands are a mixture of shrubs and bamboo; often becoming an impenetrable thicket. The benefit to the farmer in clearing monsoon forests is that this
vegetation dries out fast. Soil dries quickly and continuous shifting cultivation maintains the dense shrub mixture. Regular burning enhances grass regeneration while repeated grazing inhibits tree regrowth. Monsoon forests can regenerate into essentially three vegetation types; scrublands, grasslands, and savannas. Savannas are believed, from inference, to now exist in areas where monsoon forests were present over a hundred years ago (Monk 1997). Key pioneer species of savannas in nearby Sumba island include *Melaleuca spp.*, *Sesbania grandifolia*, tamarind (*Timonius sericeus*), and *Causarina junghuhniana*. These pioneers may take thousands of years to become a mature monsoon forest but there are no systematic studies done on monsoon forest formation for the province (Monk 1997).

**Livestock Grazing Impact on the Landscape**

In 1974, Daroesman notes that there were 145,251 cattle in Lombok at a carrying capacity of 0.7 ha per animal unit (4.5 hectares was recommended at that time) (1976). In 2004, the number of livestock on Lombok was estimated at 280,000 (Sumarto March 2004). The amount of forage available to feed a cow/calf unit in Lombok has declined to less than .5 ha. unit. In Sumba island the there are now two cattle per hectares. Cattle are important for household savings and most likely for financing Mecca pilgrimages but there is little data to support the latter supposition. The number of livestock or density found at the beginning of the 20th century is not known.

A mixed agroforestry system is found in Lombok with abundant *turi* (*Sesbania grandiflora*) (figure 11) actively planted along bunds of rice fields and sometimes in conjunction with long beans which use the trees as trellis works. *Sesbania* is cut as forage for livestock and also improves soil fertility (Monk, Fretes, and Reksodiharjo-Lilley 1997).
and authors’ survey 2006). Fences have gamal (*Gliricidia sepium*) planted in front of rice fields as living fences.

Bali cattle (*Bos javanicus*) are the most common breed of cattle in Lombok (Figure 12). This species is derived from a wild banteng (*Bos sondaicus*) which is known from fossil remains (Monk 1997). Because Bali cattle have evolved in Indonesia, they are exceptionally adapted to the variable climate and have a high reproductive rate. Monk notes that overgrazing caused a massive weed infestation of *Lantana camara* in the 1930s and 1940s that impacted cattle populations. Cattle are a huge export from Lombok and Timor. In 1995, some 53,000 cattle were needed in Jakarta alone for the Moslem fasting month of Ramadhan. The current inter-island livestock trade is flourishing but subject to excessive taxes and corruption through numerous middle-men and poorly implemented decentralization policies (Sumarto March 2004). Nonetheless, cattle are the major source of income in rural areas of Lombok (Monk 1997)

The Sasak have a well developed cut and carry forage system (figure 12) for the feeding of cows and horses and this seems complimentary to the high population densities and land shortages found on the island (Monk 1997). A history of cattle theft has led to locally overstocked corrals and overgrazed pastures. Cattle cooperatives are noted in villages to prevent rustling, improve marketing, and assist in feeding (Klock interview in Central Lombok Dec. 6, 2006).

There is a scarcity of forage during the dry season. Crop residues are utilized and several forage grasses (*Panicum, Chloris, and Brachiaria*) are actively planted in the Lombok cut and carry systems (Monk, Fretes, and Reksodiharjo-Lilley 1997). The author noted extensive cutting of weed and pasture grasses by individuals daily that were
transported by bicycle to a prospective buyer. Steep terrain usually inhibits the extensive herding of cattle and less sloping hillsides are often overgrazed. The number of cattle in Lombok at this time is unprecedented in the island’s history. The culture of cattle raising has influenced the landscape in numerous ways: inhibiting monsoon forest regrowth from grazing and burning; impacting riverine and other riparian habitats, adaptation of agroforestry plants and practices for forage production; and paying for pilgrimages.

Figure 11. Sesbania grandiflora and forage grasses planted alongside rice fields. Sesbania was encouraged for planting through government and NGO grazing management programs. (Photos by John Klock, Oct. 2006)

Figure 12. Bali cattle (*Bos javanicus*) a prolific breeder, is the most common breed in Lombok. The second image shows forage grass that has been cut and carried to livestock. (Photo by John Klock, Jan. 2007)
River Change over Time

The rice economy that has supported Lombok for over 300 years has significantly impacted rivers. All of the 33 rivers in Lombok have been altered through historic anthropogenic influence with most of this change coming from intensive rice agriculture and accompanying irrigation infrastructure. The Balinese Hindu and Sasak manipulated waterways for subak irrigation. Subak in West Lombok prior to the Dutch period were administered as units defined by small dams (pengempels) (Hagerdal 2001). The subak of old in Lombok was controlled by ruling houses who appointed officials for constructions and distribution of water (pekasih or pembekel pekasi (Gerdin 1982). The Dutch colonial period created at least 8 modern dams and diversions in Lombok encompassing an expansion of 17,000 hectares of irrigable rice land (VanDerKraan 1980). The post-WWII period saw the Indonesian government and international development funding create an additional 13 dams of various capacities up until the 1990’s. The Indonesian government efforts were predominantly focused on the Critical Areas in Central Lombok. There are now over 191 irrigation projects in Lombok irrigating at least 107,000 hectares. Of this amount, 85,106 ha. or 80% involves water derived from weirs while a further 21,930 is extracted from embung (impounded micro-catchments) and dams. High-yielding rice varieties have created a huge demand for water and required significant irrigation infrastructure.

Lombok rivers are of short length while drainages are steep. Higher flows take place during the rainy season and dramatic seasonality is experienced with flows dropping to a minimum during the dry season or drying up altogether (Nippon Koei Co. 1995; Monk 1997). There are few undisrupted parts of rivers in Lombok. Figure 13. is an
artistic rendering of a photograph that depicts the Dodokan river in 1895 (Cool 1896). In this image, there are planted palm trees and secondary regrowth of bamboo from a previous disturbance. The flat topography denotes a slower river movement of the central plain.

Figure 13. Dutch rendering of a photo of the River Djangkok (Jangkok) from the Dutch Military expedition in 1894 to Lombok (Cool 1896)

Ecologically, the now locally vanished estuarine crocodile can provide clues to past Lombok river landscapes. The estuarine crocodile (Crocodylus porosus) was endemic to Lombok and hunted in Lombok as identified in Dutch photographic images (RoyalNetherlandsInstitute 2007) (see figure 14). Crocodiles are associated with brackish water (mangrove swamps), freshwater rivers and grass swamps. Nests are created on lakes in Papua New Guinea from aquatic plants growing at the edge of the water. The species is gone from most rivers and rarely sighted in West Nusa Tenggara.
Province. The cause of this decline is most likely hunting and diversions of water from rivers and the drainage of wetlands for rice cultivation. The lands that support wet rice irrigation are often the same lands that are considered ecological wetlands. Slow moving, low gradient rivers are prime crocodile habitat as well.

Figure 14. Estuarine Crocodile in Lombok (1940) (RoyalNetherlandsInstitute 2007)

Mangroves have been completely removed from the coasts of Lombok within the past three decades from clear-cutting for construction or fuel requirements for coral burnings (Monk 1997). Monk notes that the tourist area of Kuta is centered on previously mangrove land.

There have been numerous fish introductions into Lombok with earliest records dating back to introductions in 1895 (Monk 1997). Carp were introduced in 1925 and five species of freshwater fish were brought from Java in 1941 and bred and distributed throughout the island. In 1947, increasing numbers of other undetermined fish were released into rice fields (Monk 1997). The increased connectivity between irrigation canals and rivers has also see migration of non-native fish into rivers. The decline of endemic species of fish has not be studied to any great length.
Figure 15. shows a current day river in Ampenan. Pollution has played a role in river decline in Lombok. River drainages seem to be the logical place for garbage deposition, especially since garbage production exceeds removal capacity in cities. Plastic bags combined with explosive growth of the plant, water hyacinth, inhibits water flow in rivers, clogs pipes and canals leads to flooding. Garbage deposition in rivers also contributes to disease problems such as malaria, dengue fever, and diarrhea. Lombok has particularly virulent strains of malaria and dengue fever.

Discussion

1. Religious Structures and Pilgrimages

The number of mosques in Lombok has increased by over 1500 percent since the 1930s. In 1930, there were an estimated 171 mosques (extrapolated) while today there are 2522. The population has increased from around 700,000 in 1930 to about 2.9 million people today. This is an over 414% increase in population during the 1930 to 2008 time period. Hajj numbers have likewise increased from an extrapolated 426 in 1930 to about
2070 today. This represents an increase of 485% over a 78 year period. The increase in haji has implications regarding political, economic, and social influence at the village. Village level religious changes might include less communal forms of behavior during disaster or drought as well as savings-oriented behavior oriented towards making the pilgrimage.

2. Springs

A toponymical study of spiritual places like Gunung pengsong or Gunung hadji revealed a pattern where Gunung pengsong was found in both tourist and topographical maps but no such pattern was detected for Gunung hadji. Interviews in villages surrounding these mountains could clarify the record on their naming. The use of the name aik was prevalent in over 8% of villages. This suggests that villages are named after resources and have identification with springs. Springs and forest groves have been protected historically. Recently, there have been studies suggesting that numerous springs have dried up on Mt. Rinjani. The exact cause of this is unknown but the Lombok Post reports that 466 springs have been lost throughout the province over a period of 24 years (Lombok Post June 13, 2005). The Lombok Post also mentions that there were 712 springs in Lombok and Sumbawa in 1995 but only 114 by 2000 (Lombok Post Nov. 27, 2005). What is not known is the context of how springs were utilized, shaped, and transformed over time in addition to the spiritual connection to the village.

3. Forests

The historic vegetation in the early 1900s in the occupied parts of Central Lombok is suggested to be monsoon forest (both moist and dry deciduous) with smaller
patches of intermittent scrublands, grasslands, and savannas. Scrublands represent a key vegetation entity for which to understand the past 100 years of anthropogenic activity.

This paper assumes that shifting cultivation in Lombok was always the back-up in case of rice crop failure. During times of strife, shifting cultivation meant survival, even in the drier and more infertile parts of the South. Central Lombok forests are proposed here to be a sanctuary buffer zone to temporarily reside in for a few years during times of war or disaster. Lombok’s population has been frequently regulated by famines, epidemics including smallpox, cholera, and malaria, and earthquakes and volcanic eruptions.

Figure 16 shows this buffer zone. Old fields following traditional modes with low carrying capacities allowed for a successful nutrient regeneration period before repeated cultivation. In Sapit, Lombok, villagers typically returned to abandoned fields after the secondary growth became taller than men (Monk 1997). As population densities grew all over Lombok, the fallow periods became shorter. Ecologically, this means that secondary monsoon forests might be returned to every 21 years or so, but with more occupants, the period of return would be shorter. Exemplary studies of integral shifting cultivation in Southeast Asia are noted by Conklin and Pelzer (1957; Pelzer 1945). If immigration and or policy prohibited movement to other forest sites, a more intensive cropping rotation would ensue but with poor regeneration and a possible transition into scrublands (Monk 1997).
In dry deciduous and moist deciduous monsoon forests of Central Lombok, prior to the end of the 1800s, this paper conjectures that the shifting cultivation practices in Central Lombok were sustainable. That is, the overflow at any given time from East Lombok or West Lombok could be accommodated by the monsoon forest and allow for adequate secondary forest regeneration. The Central Lombok lands were able to accommodate the waves of migrants that arrived after disasters. For example, following the Tambora eruption on Sumbawa or the Balinese war of the 1890s and ensuing famine. As the population in Lombok increased, the available sites for pioneering migration
began to shrink. Interestingly, Lombok also has a high transmigration rate to other islands of the archipelago.

4. Cattle Grazing and Riparian Change

The number of cattle over the last 30 years has doubled to over 280,000. There are several possible reasons for this increase. Decentralization by the Indonesian government in the 1990s led to, in theory, more opportunities to export cattle to Java, especially during Ramadhan. Raising cattle is the main source of savings for most farmers. Cattle raising is also a way of saving for the devout to travel to Mecca. Less participation by village leaders and patrons in ritual feasts has impacted the communal safety net found in traditional Lombok village life.

Agroforestry practices including cut and carry, and the planting of grasses and trees have increased the carrying capacity of cattle of cattle on the island. Cattle in Lombok have a very small amount of grazing land per head and are often raised in nearby corrals or pastures to avoid theft. This increase in cattle density has contributed to already overgrazed conditions.

Rivers have been altered for hundreds of years in Lombok and at the start of the 20th century, the human population has doubled and then doubled again. The amount of available pioneering lands has declined. Wetlands have been drained for reservoirs and rice fields virtually all of the mangrove have been removed. The settlement of Central Lombok by the Netherland Indies government was not without consequence. The goal was to increase rice production for export earnings and the best way to do this was to create more rice lands. The increase in human population in a drought prone area like south central Lombok is risky at best. Soils are historically poor and irrigation flows are
erratic. This idea of settling a population in a drought prone area is discussed in depth by Van der Kraan,

**Conclusions**

This paper has chronicled historical descriptions of the Lombok landscape hydrology as well as alterations to the watersheds and fields from the early 1890s to the present day. Key human adaptations that are readily visible on the landscape include pioneer migration to forested areas, the increase in mosque and cattle numbers and the enhancement of agroforestry technology through the planting of grasses and trees. Spring boxes and weirs allowed for the successful capture of water to irrigate the lowland areas. Cattle are the *Bos javanicus* breed, or Bali cattle, which are a prolific slender animal and historic prodigy of wild cattle found in Indonesia. The increase in cattle population could be related to decentralization of the beef market and the lifting of restrictions on inter-island trade of livestock. The numbers of cattle are at a historic high compared to a century ago. Other factors such as the raising of cattle and the change in individual saving patterns may be at work in relationship to fulfilling one of the five goals of Islam.

Back in the early 1900s the monsoon forest was abundant in Lombok. A sense of what this forest type looked like can be seen in protected groves surrounding springs in the higher elevations. The Sasak and Balinese people have strong ties to springs both culturally and spiritually as seen in the Lingsar festival every year. Spring place names can give villages a sense of historical and cultural identification. At the start of the 20th century, human population density was still not high in the drought lands of Central Lombok. A key turning point in the human ecology of Central Lombok was the opening of rice lands with the increase in
irrigation infrastructure as highlighted by Van der Kraan, Leeman, and Brennan.

Initial policies to encourage rice land settlement in Central Lombok were later altered as
the number of landless individuals increased. The Lombok people possess a remarkable
ability to adapt and survive. In the course of this research, one questions the continued
focus on wet-rice agriculture in the context of a preferred resilience ‘state’ especially in
drier areas. Maintaining rice as a primary staple in south central Lombok appears to limit
options and exacerbate poverty.

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Appendix 1. Graph of Mosque and Pilgrimages, Calculations

- This number was calculated by counting mosque symbols on Dutch topographic maps from the years 1926 to 1931. There were no large scale maps available for East Lombok, so the number was extrapolated based on population.

Table 1a. Mosque Counts

<table>
<thead>
<tr>
<th>Year and Population</th>
<th>Calculation of Mosque #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930*</td>
<td>Hand count of maps for West and Central Lombok was 129</td>
</tr>
<tr>
<td></td>
<td>Assumes that East Lombok had 1/3rd of the population</td>
</tr>
<tr>
<td></td>
<td>129 x .33 = 43</td>
</tr>
<tr>
<td></td>
<td>43 + 129 = 171 (hand count + East Lombok extrapolation)</td>
</tr>
<tr>
<td></td>
<td>AND</td>
</tr>
<tr>
<td></td>
<td>1,700,000/701,204 = .41%</td>
</tr>
<tr>
<td></td>
<td>.41 x 1437 = est. 574</td>
</tr>
<tr>
<td>1930** 701,204 (Leeman 1989)</td>
<td>171 AND 574 Mosques in 1930</td>
</tr>
<tr>
<td>1975 1,700,000***</td>
<td>2,950,105/1,700,000 = .57%</td>
</tr>
<tr>
<td></td>
<td>.57 x 2522 = est. 1437 mosques in 1975</td>
</tr>
<tr>
<td>2005 2,950,105 (BPS 2006)</td>
<td>2522</td>
</tr>
</tbody>
</table>

Table 1b. Haj Counts

<table>
<thead>
<tr>
<th>Year and Population</th>
<th># of Pilgrimages to Mecca</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930 701,204 (Leeman 1989)</td>
<td>426****</td>
<td>1,700,000/701,204 = .41%</td>
</tr>
<tr>
<td>1975 1,700,000</td>
<td></td>
<td>.41 x 1040 = 426****</td>
</tr>
<tr>
<td>1974/75</td>
<td>1040 (Source: Daroesman 1976:69) for province</td>
<td>Assumes a relationship between mosque # and Hajj. 1040/2072 = .501% x 100 = 50.1%/21 years = 2.3% growth rate in Mecca pilgrimages from 1974 to 2005.</td>
</tr>
</tbody>
</table>
Appendix 2. Historic Vegetation, Characteristics, and Degradation Stage (Adapted from Monk (1997))

<table>
<thead>
<tr>
<th>Historic Forest or other Vegetation Formation</th>
<th>Elevation/Villages</th>
<th>Rainfall</th>
<th>Disturbance</th>
<th>Approx. % Area of Lombok Today</th>
<th>Characteristics and Dominant Species</th>
<th>Degradation or Secondary Veg. Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Moist Deciduous Forest (monsoon forest)</td>
<td>Lowlands to 1,200 m. Aik Bukaq, Aik Beriq, Teratak, Batu Kliang Utara, Setiling</td>
<td>1500 – 4000 mm rain; 4-6 dry months</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>Ficus spp., Tamarindus spp. , Annona squamosa, Pterocarpus indicus, Tectona grandis</td>
<td>From burning: Imperata (alang-alang) grassland with scrubland</td>
<td></td>
</tr>
<tr>
<td>Tropical Dry Deciduous Forest (monsoon forest)</td>
<td>Below 1000 m. 12 Villages in southern half of study area</td>
<td>&lt;1500 mm rain; 6+ dry</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>Tamarindus spp. , Annona squamosa, Pterocarpus indicus, Sterculia spp., Calophyllum spp., Aleurites spp.</td>
<td>Scrubland, grassland or Savanna</td>
<td></td>
</tr>
<tr>
<td>Tropical Dry Evergreen (monsoon forest)</td>
<td>Below 1000 m. Villages in southern half of study area</td>
<td>&lt;1000 mm rain, 9+ dry months</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>Schleichera oleosa, Albizia chinensis</td>
<td>Scrub or grassland</td>
<td></td>
</tr>
<tr>
<td>Tropical Thorn Forests (monsoon forest)</td>
<td>Below 1000 m. Villages in southern half of study area</td>
<td>&lt;1000 mm rain, 9+ dry months</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>Acacia spp.</td>
<td>Scrub or grassland</td>
<td></td>
</tr>
<tr>
<td>Scrublands (belukar) Secondary Vegetation</td>
<td>Below 1000 m. Villages in southern half of study area</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>~8.17%</td>
<td>Thicket, shrubs, stunted trees, bamboos, Melastoma spp., Tetracera spp., Malvaceae family</td>
<td>Savanna</td>
<td></td>
</tr>
<tr>
<td>Mixed Savanna</td>
<td>Below 1000 m. Villages in southern half of study area</td>
<td>&lt;1000 mm rain 9+ dry months</td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>9.32%</td>
<td>Albizia chinensis, Eucalyptus alba., Melaleuca spp., Tamarind spp. Palm savanna species include Borassus spp and Crypha spp.</td>
<td></td>
</tr>
<tr>
<td>Alang-alang</td>
<td></td>
<td>Grazing, shifting cultivation, grass firing</td>
<td>.89%</td>
<td>Imperata cylindrica</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 3. A Chronology of Documented and Significant Landscape Ecosystem Change, and Plant Introductions

<table>
<thead>
<tr>
<th>Time frame, Disturbance, Reference (see footnotes)</th>
<th>Specific changes on the landscape including location, and plant introductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tambora eruption of 1812 could have forced East Lombok residents into Central Lombok and West Lombok. Up to 50 cm of ash all. Crop, livestock poisoning from fluoride. Human diarrheal diseases. Unconfirmed deaths from Tambora in Lombok are up to 40,000, perhaps 1/4th of the population. Migrants subsequently cleared forests for shifting cultivation.</td>
<td>Tambora in Sumbawa, 25 to 50 cm ash fall in Central Lombo with possible fluoride poisoning of water and livestock. sc, aa</td>
</tr>
<tr>
<td>Generational shifting cultivation&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Lombok</td>
</tr>
<tr>
<td>Burning of West Nusa Tenggara monsoon forests for multiple generations for hunting and shifting cultivation (Monk 1997)</td>
<td></td>
</tr>
<tr>
<td>The movement of large numbers of Central Lombok people to East Lombok. In East Lombok, a combination of crop disease and selling a large part of the previous two rice crops to pay for arms resulted in a food shortage (Brennan 1984). Van der Kraan notes that it was reported to the Dutch that the Sasak were eating banana trunks (VanDerKraan 1980)</td>
<td>1891-1899 Central Lombok destruction of villages, crops and irrigation work by the Balinese. Food shortages in central Lombok caused many Sasak to flee to the East. By 1894 East Lombok began to experience food shortages. By 1894 there was a shortage of food in Central and East Lombok. Private stocks of rice were sold to buy arms. Plough cattle were in short supply.</td>
</tr>
<tr>
<td>From 1916 to 1925 forest land was opened in Central Lombok (Judd notes near the village of Iaq Iquk)(Judd 1978).</td>
<td>1894 – 1940s Dutch Period Forest Opening&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dutch removal of swamp ecosystem to remove malaria, dengue, and other disease threat (Leeman 1989)</td>
<td>Dutch Period Wetland Drainage&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>During World War II, there was a clearing of hill forests near Gapuk, Lombok. Villagers were forced to grow cotton and after the occupation, the land turned into Imperata sp. and further shifting cultivation degraded the lands even more (Monk 1997)</td>
<td>World War I&lt;sup&gt;10&lt;/sup&gt; Logging and Enforced Cultivation</td>
</tr>
</tbody>
</table>

<sup>4</sup> Tambora eruption of 1812 could have forced East Lombok residents into Central Lombok and West Lombok. Up to 50 cm of ash all. Crop, livestock poisoning from fluoride. Human diarrheal diseases. Unconfirmed deaths from Tambora in Lombok are up to 40,000, perhaps 1/4th of the population. Migrants subsequently cleared forests for shifting cultivation.

<sup>5</sup> Burning of West Nusa Tenggara monsoon forests for multiple generations for hunting and shifting cultivation (Monk 1997).

<sup>6</sup> The movement of large numbers of Central Lombok people to East Lombok. In East Lombok, a combination of crop disease and selling a large part of the previous two rice crops to pay for arms resulted in a food shortage (Brennan 1984). Van der Kraan notes that it was reported to the Dutch that the Sasak were eating banana trunks (VanDerKraan 1980).

<sup>7</sup> From 1916 to 1925 forest land was opened in Central Lombok (Judd notes near the village of Iaq Iquk)(Judd 1978).

<sup>8</sup> The forest separating West from East Lombok was removed in the Dutch period to bring the entire Central Plain under cultivation (VanDerKraan 1980).

<sup>9</sup> Dutch removal of swamp ecosystem to remove malaria, dengue, and other disease threat (Leeman 1989).

<sup>10</sup> Logging and enforced cultivation during World War II in Lombok and other parts of Nusa Tenggara (Monk 1997).

<sup>11</sup> During World War II, there was a clearing of hill forests near Gapuk, Lombok. Villagers were forced to grow cotton and after the occupation, the land turned into Imperata sp. and further shifting cultivation degraded the lands even more (Monk 1997).
<table>
<thead>
<tr>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late 1940s logging in SW Peninsula of Lombok</td>
<td>SW Lombok</td>
</tr>
<tr>
<td>Present Lime burning, brick making, pottery industry</td>
<td>Lombok</td>
</tr>
<tr>
<td>1900 to present Planting of Leucaena leucocephala</td>
<td>Lombok, La on farms</td>
</tr>
<tr>
<td>Conversion of dry fields to home gardens (kebun)</td>
<td>Lombok, and Sesaot village, Lombok ke on dryfields with ca, co</td>
</tr>
<tr>
<td>1960s to present Planting of Sesbania for fodder, fuelwood, and green manure</td>
<td>Southern Lombok, Lombok, sg</td>
</tr>
<tr>
<td>1960s to present Planting of Gliricidia sepium (gamal) as a living hedgerow in front of rice fields</td>
<td>Central Lombok</td>
</tr>
<tr>
<td>1960s Coffee planting</td>
<td>Upland areas of Lombok, co</td>
</tr>
<tr>
<td>Famine of 1965</td>
<td>10,000 to 50,000 deaths, especially in the critical area of south-central Lombok (Brennan 1984)</td>
</tr>
<tr>
<td>1975 Deforestation</td>
<td>Central and South Lombok</td>
</tr>
<tr>
<td>2000-20005 Sesaot, Senaru and Rempek</td>
<td>Sesaot is a large upland village in W. Lombok Rempek is an upland community in N. Lombok</td>
</tr>
</tbody>
</table>

---

12 Gerdin notes that this peninsula was once covered by “rain forest” was cut down by lumber exporters in the late 1940’s (Gerdin 1982).
13 Lime burning using coral, brick making, and pottery industry all command huge amounts of fuelwood on Lombok (Monk 1997).
14 *Leucaena leucocephala* is called *lamtoro* in Indonesia. It was introduced into Southeast Asia from Central America in the 1600s with the Spanish and used as a shade tree for coffee, vanilla, and kapok. It is drought resistant (Monk 1997).
15 Occurs were land pressure is acute and is a way of transforming dry fields into permanent banana gardens with robusta coffee (Monk 1997; Roshetko 2002).
16 *Turi* or *Sesbania gradiflora* is planted on paddy land in Southern Lombok and in hedgerows on hills interspersed with annual crops. The intense pressure on land has led to this system of planting fodder for cattle. It is considered a cut and carry method.
18 Fisher notes that coffee was introduced to upland areas in the early 1960s (Fisher 1999). Van der Kraan mentions that the Balinese prohibited the planting of coffee outside of personal use, during the later part of the Balinese period due to fear that it would attract Dutch interest (VanDerKraan 1980).
19 Unfavorable climate and political change resulting in an anti-communist purge in Lombok (and elsewhere in Indonesia) resulted in anywhere from 10,000 to 50,000 deaths.
20 Large areas denuded from logging in Pelangan (SW Peninsula). North of Lembar indigenous forests have disappeared. Near Sengkol in Central Lombok the hills have been completely denuded (Crippen 1975).
Fisher mentions that Sesaot and Rempek attracted immigrants in the 1950’s who were attracted by employment in timber and forest products industries. Senaru received resettled Balinese following the eruption of Gunung Agung volcano in Bali in the mid 1960’s. There were also translocated Sasaks relocated to Senaru in the 1970s and 1980s (Fisher 1999).

Logging concessions and illegal logging are still present in Rempek, and Sesaot (Fisher 1999) with illegal logging still active in most upland forested areas of Lombok. Unclear forest reclassification, failure to license concessionaires, and inconsistent reforestation by the government have all increased conflict.

The population density in Lombok is extremely high at 526 persons/km². (Fisher 1999)

Cut and carry systems on Lombok are productive for the limited land space. Introduced grasses are grown along rice fields, ditches, and sides of roads and include *Panicum maximum* (Guinea grass), *Chloris gayana*, and *Brachiaria decumbent.*

In 1976 Daroesman notes that West Nusa Tenggara as of 1974/75 was seriously overgrazed. In Lombok there were only 0.7 units of grazing land per animal unit. Furthermore overgrazing is creating erosion problems, and altering botanical compositions (Daroesman 1976).

Cattle population in 1974 on Lombok was 145,251 while in 1999 the population was 280,000 (Daroesman 1976; Sumarto March 2004)
Appendix 4 Ecological and Political Change in Lombok

1815-1890s
- 1891-99 Balinese war in Central Lombok, destruction of crops, irrigation, and population at 2 million
- Destruction of Central Lombok Forests by colonial government, 1930 population at 700,000
- 8 dams constructed during Dutch period to 1976 population at 2 million
- 1815 Tambora eruption, possible migration to and in Lombok

1900-1940s
- Clearing of Central Lombok Forests by colonial government, 1930 population at 700,000
- 1920s population at 700,000
- 1930 clearing of last remaining mangrove in Lombok

1940s-1960s
- 1950s-60s Famine resulting in 10,000 to 50,000 deaths
- Cattle population in 1974 at 8 dams constructed during WWII
- Agroforestry Crops and technologies enhanced

1960s-1980s
- 1965-66 Famine resulting in 10,000 to 50,000 deaths
- Cattle population in 1974 at 13 dams created in Lombok in 1980s and 1990s
- 1976 population at 2 million
- 1960’s – Present time. Lime burning using coral, brick making, and pottery industry all command

1990s-2008
- Agroforestry Crops and technologies enhanced
- Cattle population in 1999 at 13 dams created in Lombok in 1980s and 1990s
- 1990s, centralization in provinces
- 1990 population at 2.9 million
- 13 dams created in Lombok in 1980s and 1990s
- 1990 population at 2.9 million

1990s
- 1965-66 Famine resulting in 10,000 to 50,000 deaths
- Cattle population in 1974 at 8 dams constructed during WWII
- 13 dams created in Lombok in 1980s and 1990s

2008
- Cattle population in 1999 at 13 dams created in Lombok in 1980s and 1990s
- 1990 population at 2.9 million
- 13 dams created in Lombok in 1980s and 1990s
- 1990 population at 2.9 million

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