CHAPTER 4
DISCUSSION

The vegetational history and the climatic changes at the two lake sites viz Manasbal and Mansar is reconstructed on the basis of the pollen analysis. The age of the sediments is based on carbon dating which goes back to 3500 B.P. in the case of Manasbal lake, 2000 B.P. in the case of Mansar lake MS-7 and 1500 B.P. in the case of Mansar lake MS-5. The vegetational profile is represented by the pollen diagrams of the respective sites. In each pollen diagram there are periods of dominance of different species which are indicated in the pollen profile as zones and subzones which represent smaller units (Palynozones or Biostratigraphic units) for the finer description of vegetational composition and their distributional pattern in time and space (see Figs. 7, 8, 9 & 10). The climatic changes are largely determined on the basis of the frequencies shown by the arboreal components. The dominance of aquatics and the herbal taxa has also been taken into account to supplicate the overall palaeoenvironment.

Vegetational pattern and climatic correlations

Manasbal Lake

The vegetation of Manasbal site is categorized into five pollen zones. The early phase distinguished as zone - a in the pollen diagram (Figs. 9 & 10) reveals a dry temperate climate with the dominance of angiosperms including herbs like Artemisia, Poaceae, Plantago and broad leaved trees viz. Quercus, Juglans and Fraxinus. The gymnosperms show relatively a low value except Abies. Other broad leaved trees like Betula, Ulmus, Carpinus, Salix and Corylus are also present but they show lower values than Quercus and Juglans. High values of
*Artemisia* and presence of *Cerealia* pollen along with pollen of Amaranthaceae - Chenopodiaceae complex and *Plantago* indicate that cultivation had commenced during this period. Absence of aquatic plants like *Typha*, *Myriophyllum*, *Potamogeton*, *Cyperaceae*, *Nymphaea* indicates low level of the lake and dry conditions.

The following zone - b is divided into four subzones b₁ to b₄. Gradually a climatic change is noted in subzone - b₁, with the beginning of a cooler phase resulting in a sharp rise in *Pinus* pollen followed by an increase in the values of other conifers like *Picea* and *Cedrus*. At first *Abies* shows a reduced value but there is an increase in its value subsequently. Among the broad leaved trees *Betula*, *Carpinus* show an increased value. *Quercus*, *Ulmus* and *Alnus* are present in the lower region of the zone and then their value decreases. Among the angiosperm, herbs like *Artemisia*, Amaranthaceae/ Chenopodiaceae, *Plantago* show a reduction along with *Cerealia* pollen which nearly disappears. This may indicate a decline in agricultural practice during this period due to chilling of climate as recorded by the domination of conifer forest. *Potamogeton* which grows in cooler climate also makes an appearance along with other aquatics like *Typha*, *Cyperaceae* and *Salix*. This suggests the possibility of precipitation resulting in the rise of the level of the lake with the growth of the aquatic plants. Pteridophytes also show a good representation due to cooling of the climate. This moist cool temperate conditions show a slight warming in subzone - b₂ where there is a reduction in the value of conifers. The thermophilous taxa like *Quercus*, *Carpinus*, *Ulmus*, *Alnus*, *Olea*, *Salix*, *Artemisia*, *Cerealia* were the dominant genera of this zone. *Plantago* and Amaranthaceae/ Chenopodiaceae also increase in value. Concomittantly with a change in the cool and moist climate other taxa like those of Caryophyllaceae, *Urticaeae*, *Asteraceae*, *Apiaceae* also show
sporadic representation. *Potamogeton* shows a low value. The frequency of Cyperaceae remains consistent while *Typha, Nymphaea* and *Myriophyllum* are absent. This dry warm phase seemingly lasted only for a short period as indicated by the rise in the values of *Pinus* after a short interval in subzones $b_3$ and $b_4$ along with consistent values of *Betula, Juglans* and *Quercus* among the broad leaved trees which flourish in a warm moist temperate climate. Aquatics are represented by *Potamogeton, Myriophyllum, Typha*.

Optimal condition of climate seemed to have developed in the following zone - c which is reflected by reduced values of conifers and a better establishment of broad leaved taxa like *Quercus, Carpinus, Juglans, Ulmus, Alnus, Olea*. Presence of *Corylus* was persistent in the vegetation of this zone. Among the herbaceous forms *Cerealia, Artemisia, Plantago, Amaranthaceae/Chenopodiaceae* and *Poaceae* dominate. The pollen assemblage in which *Cerealia* pollen are well represented suggests that cereal cultivation was maximum during this phase. Other herbaceous forms growing in association with these taxa were representatives of *Urticaceae, Asteraceae, Caryophyllaceae* and *Apiaceae*. These were also in their best growth in this zone and their presence was continuous. The floristic composition of this phase depicts a period of maximum warmth and the presence of the aquatic plants in fairly good values suggests rise in the lake level. This may have been due to melting of ice at higher altitudes as the climate had become warmer.

In the zone - d there is slight rise in the value of *Pinus* and a decrease in the frequency of other conifer genera. This reveals continuation of warm conditions. Broad leaved constituents however remain unchanged. *Poaceae* and *Cerealia* show a marginal increase in their values while aquatics show a slight fall except
Myriophyllum which shows an increase. The climate during this phase (zone - d) depicts continuation of the warm conditions.

In the succeeding phase (zone - e) the gymnosperm taxa continue to decrease and there is increase in the broad leaved species and the herbaceous forms. Among the aquatic plants Typha shows a greater value than Potamogeton. This again reveals a warm climate with moist conditions.

Thus the overall pattern of vegetation at the Manasbal lake reveals oscillations of climatic cycles. At about 2000 - 2300 B.P. the vegetation development was at its climax with a warm and moist climate. Apparently, this was a period of prosperous economy.

The arboreal to non-arboreal pollen ratio is nearly equal in zone - a but the ratio of arboreal pollen increases in the subsequent zones except in the middle of subzone - b₂ (at a depth of 420-435cm) where their ratio was found equal.

The broad-leaved, conifer ratio (B/C) is higher (1.4) in the beginning of zone - a but it becomes almost equal towards the upper limit. Subsequently in the zones b, c & d the broad-leaved conifer ratio decreases except at a depth of 285-295 cm in zone - c and at a depth of 235-255 cm in zone - d. In the zone - e the ratio is nearly the same (see table 9).

On standardizing the above B/C ratio we get values between 0.1 - 1. The present B/C ratio at Manasbal is 0.5-0.6 (Agrawal,1992 ). Values less than 0.5 indicate cooler conditions and those above 0.6 indicate warmer conditions of climate than those of the present times. Based on this we can infer that zones a, c and e show warmer conditions with their ratios between 0.5-1 while zone b shows cooler conditions than the present times with ratios between 0.1-0.4. Zone d shows ratio between 0.2-0.6 indicating cooler conditions with warm phases in
between (see table 12). This is also reflected in the vegetation of Manasbal as described earlier.

Inversion of 14C Dates

Fig. 11 depicts the radiocarbon age of the organic matter of the core sediments of Manasbal lake at different depths.

The graph shows reversal of dates from the depth of c. 200 cm. From this point as we go deeper up to the depth of 400 cm we find younger dates instead of showing an older period. This inversion of 14C dates may have occurred either due to the deposition of the younger soil from the catchment area or due to anticlinic upliftment (upfolding). The inversion of the soil sequence is also denoted floristically as the zone - d resembles the subzone - b3 and appears to be its continuation while zone - c which lies in between has a different kind of vegetation representing the younger date of the top of the sedimentary profile (zone - e).

Mansar MS - 7

The vegetation of Mansar MS-7 is categorized into six pollen zones and two subzones in the chronological sequence. The early phase of the pollen profile i.e zone - a marking the base of the present sedimentary core profile reveals a high value of conifer Abies. The other conifers Pinus, Picea and Cedrus show relatively lower values. The broad leaved constituents like Quercus, Alnus and Olea show a better representation than Salix and Betula which show stray occurrence. Corylus, Carpinus, Juglans, Ulmus and Celtis are absent. The preponderance of Abies among the conifer flora and a low value of thermophilous species during this period indicates a cool temperate climate. Artemisia, Cerealia, Amaranthaceae/Chenopodiaceae, Mallotus and Caryophyllaceae are among the herbaceous taxa which are present in the zone with low values. Only Poaceae
CARBON DATING (\textsuperscript{14}C) OF SOIL PROFILE OF MANASBAL LAKE

Fig. 11
shows a high value. The aquatics are well represented. Cyperaceae shows a higher value than other aquatic species like Typha, Polygonaceae and Potamogeton. The presence of a good number of aquatic taxa indicates a high level of the lake. The occurrence of Phragmites which grows along the margins of the lake along with Cyperaceae and Typha denote the reed swamp community. Pteridophytes are also represented moderately in this phase.

In the subzone - b1 the values of Abies and Pinus show a decline but there is again an increase. The pollen assemblage shows dominance of broad leaved tree taxa. This indicates that the climate had started warming in this zone although it was still relatively cool. Quercus, Alnus and Olea which were already present become well established along with Salix, Betula, Ulmus, Celtis, Juglans. Ephedra, Carpinus and Corylus are represented sporadically. No change is recorded in the herbage component of the zone except that Artemisia, Amaranthaceae/Chenopodiaceae and Poaceae show a decline in their values. Oldenlandia is well represented followed by Mallotus and Urticaceae. Oldenlandia pollen is generally indicative of higher precipitation of sub-humid and humid regions. Other forms like Plantago, Acanthaceae, Caryophyllaceae and Asteraceae are sporadic. Aquatics maintain their unchanged representation. These features suggest the occurrence of a moist environment.

The environment continued to become warmer in the succeeding phase subzone - b2 as a result of which the pollen frequency of Abies declined and that of Pinus and Quercus increased. The climate became favourable for the growth of Alnus, Olea, Salix, Betula, Ulmus, Celtis and Juglans. Among the herbage components of the vegetation the sharp rise in the values of Artemisia, Amaranthaceae/Chenopodiaceae, Poaceae and Urticaceae and a marginal increase in the values of aquatics like Cyperaceae and Typha and the pteridophytes indicate
the existence of a warm, humid temperate climate which prevailed for a longer period but there were minor climatic variations as we find from the fluctuations in the values of tree species.

A relative increase in the values of *Alnus, Quercus, Salix, Cordia, Dodonaea, Artemisia* and *Amaranthaceae/Chenopodiaceae* is noted in the zone - *d* which suggests that the climate was warm but less humid which affected the growth of aquatic plants leading to their absence as in the case of *Potamogeton* or those which survived showed a reduced value. Besides *Artemisia* and *Amaranthaceae/Chenopodiaceae* the other herbaceous taxa were either absent or poorly represented. On account of drier conditions the pteridophytic flora also show a decline during this phase although a rise in its frequency is noticeable towards the top of the profile.

Further stage of climatic change is marked in zone - *e* where a sharp rise of a warm dry subtropical climate is noted favouring a better representation of herbage like *Artemisia, Poaceae, Amaranthaceae/Chenopodiaceae, Mallotus, Oldenlandia, Urticaceae, Caryophyllaceae*. Other taxa which indicate a warmer condition are *Plantago, Acanthaceae, Asteraceae, Apiaceae* and *Ranunculaceae* are also present. *Brassicaceae* also make an appearance in this zone. The climatic conditions were suitably developed for *Dodonaea* and *Cerealia* which also show a marked rise in their values. The tree species which had a better representation in this zone than other species were *Alnus, Olea, Quercus* and *Salix*. Due to development of warmer climate temperate conifers like *Abies* and *Cedrus* decline to a lower value and relegate their dominating position. Among the aquatics *Typha* and *Cyperaceae* become well represented while *Polygonaceae* and *Potamogeton* almost disappear or show a very negligible percentage which may indicate that there was a fall in the level of the lake on account of dryness. The
decline of pteridophytic flora also provide further support to the existence of the warm and dry climate during this period.

The subsequent vegetation which flourished hereafter in the zone - f of the pollen diagram shows that this type of warm climate prevailed almost up to the top of the soil profile i.e. up to the present times but relatively with a cool phase becoming favourable for the growth of Pinus, Cedrus, Picea and Alnus which become represented in the flora with a higher rate of frequency. Correspondingly there is a decline in the thermophilous species like those of Quercus, Ulmus, Celtis, Ephedra and Corylus. The herbage flora also show a decline and the forms like Artemisia, Amaranthaceae/Chenopodiaceae, Plantago, Urticaceae, Acanthaceae and Asteraceae show relatively a low value but Poaceae and Dodonaea show a better representation. The aquatic flora shows no significant change. The higher representation of Cerealia and Brassicaceae and decline in the values of tree pollen throughout these later periods may indicate a rising tendency of cultivation. The decline in the frequency of tree species may also suggest clearance of forest for the purpose of cultivation.

The arboreal, non-arboreal pollen ratio was found higher in zones a, b, c and d which covers the depth between 150 to 40 cm from the top of the sedimentary profile. After this the ratio becomes nearly one except in the beginning of zone - e (25 cm from the top of the profile) where the ratio becomes less than one.

The broad leaved / conifer ratio is less than one except in zone - d (35 cm from the top) where the ratio was found to be one indicating that the broad leaved trees and the conifers were present almost in equal proportion.

The standardized B/C ratio at Mansar MS-7 indicates a cooler climate in zone a and the beginning of zone b with the ratios between 0.2-0.3. Thereafter the
conditions start getting warm with the maximum warmth in zone d where the ratio is between 0.5-1. The zones e and f with values between 0.1-0.5 indicates that the climate was cooler than the preceding zone. The top of the profile shows a value of 0.3 which is as of the present times. These climatic conditions depicted by the B/C values are in concordance with the climate discussed above (also see table 12).

**Mansar MS - 5**

The vegetation of Mansar MS-5 is categorized into five pollen assemblages which are indicated in chronological sequence as zones in the pollen diagram.

The whole of the Mansar MS - 5 pollen profile depicts warm and dry climatic conditions extending from the base of the profile right upto zone - d which lies below the depth of 20 cm from the top surface.

The prevailing climate favoured the growth of chirpine forest with poor representation of other conifers like Cedrus and Picea. Abies however attained a higher value. Similarly among the broad - leaved trees Quercus which grows with Pinus showed a higher value than Abies. Next to Quercus, Alnus and Olea flourished better than other broad leaved trees. The remaining thermophilous species like Salix, Betula and Juglans showed a sporadic rise and fall in their frequencies while Ulmus, Celtis, Carpinus, Corylus showed a highly reduced value indicating their sporadic and poor representation.

The warm and dry climate is also indicated by the high percentage of taxa like Artemisia, Poaceae, Amaranthaceae/ Chenopodiaceae, Caryophyllaceae and a reduced value of pteridophytes and the aquatic vegetation. However, the pollen diagram (Fig. 8) reveals minor fluctuations in the frequency indices of the individual species indicating that there were intermittent short periods of climatic variations. The frequency curve of the conifers among the gymnosperms and
Ericaceae, Poaceae, *Dodonaea*, Cyperaceae among the herbage constituents show noticeable variations. The level of the lake seemed to be higher in the beginning as indicated by the presence of *Potamogeton* in the zones - *a* & *b*.

The zones - *c* & *d* which are dominated floristically by *Dodonaea*, Poaceae, *Artemisia* and Amaranthaceae - Chenopodiaceae complex depict a warm subtropical climate. The climate in this zone is drier than in the preceding zone and a fall in the level of the lake is indicated by a decrease in the values of *Oldenlandia* and *Potamogeton*. Within the limits of these zones representing a period between 1200 B.P. and 1000 B.P. there is an indication of better cultivation due to increasing values of *Cerealia* pollen alongwith *Plantago*, Asteraceae, Urticaceae, Liliaceae among the herbage. There is also an increase in the values of *Cordia* and *Ephedra* which is again an indication of a warmer climate. *Betula* and *Juglans* increase among the broad leaved trees and *Typha* and *Polygonaceae* among the aquatics.

In the next stage towards the top the climate had become less warm with an increase in humidity as it is marked by the decline of taxa like *Artemisia*, Poaceae, *Cerealia* and Amaranthaceae/Chenopodiaceae and increase in the value of *Dodonaea*, *Mallotus*, *Oldenlandia* and Ericaceae. Among the aquatics *Typha*, *Polygonum* and Cyperaceae show a continuity curve but some other aquatic taxa like *Potamogeton*, *Nymphaea* and *Myriophyllum* show a decline. The broad leaved trees of *Ulmus*, *Celtis*, *Betula* and *Salix* also show continuity but with highly reduced values. *Pinus* increases among the conifers but *Quercus* reduces in value. A slight rise in the lake level is indicated by the presence of deep water aquatic plants and this may be due to increased precipitation.

The ratio of arboreal/ non arboreal taxa is higher in zones *a*, *b* and upto the middle of zone - *c* which lies at the depth of 50 cm from the top and thereafter the
ratio is nearly equal except in zone - d which lies at a depth of 30 cm from the top where the ratio decreases.

As seen in table 7 the broad leaved tree/conifer ratio is less than one indicating that the conifers were higher in frequency throughout the profile.

On standardizing the above B/C ratio we get values between 0.1-1. The present B/C ratio at Mansar is 0.3-0.4. Values below this indicate cooler conditions and values above this warmer conditions of climate than those of the present times. Zones a, b, c and upto the middle of zone d indicate warmer conditions with B/C values between 0.4-1. After this the value starts decreasing indicating the cooling of climate. Zone e shows a value of 0.4 which compares with the present times. The climatic conditions indicated by the B/C values is in concordance with the climatic changes discussed above (also see table 12).

**Vegetational Classification**

The vegetational composition at the two lake sites i.e Manasbal and Mansar may be classified into the following categories:-

**Aquatic plant community**

Submerged plants: *Myriophyllum, Potamogeton.*  
Free Floating: *Nymphaea.*  
Swampy: *Typha, Cyperaceae, Salix, Polygonaceae.*

**Bushland and Herbaceous community**

*Artemisia, Amaranthaceae/Chenopodiaceae, Poaceae, Plantago,*  
*Dodonaea, Corylus, Mallotus, Oldenlandia Asteraceae,*  
Apiaceae, Brassicaceae.

**Broad leaved tree community**

*Betula, Juglans, Carpinus, Quercus, Celtis, Ulmus, Alnus,*
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<th>Total percentage of the plant groups</th>
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<tr>
<td>Ranunculaceae</td>
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<td>-</td>
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<tr>
<td>Polygonaceae</td>
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<td></td>
<td>0.4</td>
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Contd.
Contd.

<table>
<thead>
<tr>
<th>Name of plant species/family</th>
<th>MANASBAL</th>
<th>MANSAR MS-5</th>
<th>MANSAR MS-7</th>
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<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>ANGIOSPERMS : DICOTS</strong></td>
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<td>Nymphaeaceae</td>
<td>0.01</td>
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<tr>
<td>Ericaceae</td>
<td>-</td>
<td>41.81</td>
<td>0.2</td>
</tr>
<tr>
<td>Moraceae</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PTERIDÓPHYTES</strong></td>
<td>7.0</td>
<td>7.0</td>
<td>1.3</td>
</tr>
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</table>
Fraxinus, Olea, Cordia.

Conifer community
Pinus, Picea, Abies, Cedrus.

Gnetallan community
Ephedra

Pteridophytic community

Table 1 shows the percentage of pollen of different plant groups in the soil profiles of the three investigated sites. The figure 12 reveals almost equal dominance of the dicots and the gymnosperms at Manasbal and almost the same representation of the monocots and the pteridophytes whereas at MS-5 and MS-7 localities of Mansar site these plant groups show a variable dominance. At MS-5 the dicots dominated over the gymnosperms and other groups of plants in which the pteridophytes relatively show a poor representation compared to the gymnosperms, dicots and monocots while at MS-7 the gymnosperms were dominating. At both these sites the climate was seemingly less moist as compared to Manasbal where pteridophytes are better represented.

The Climate of Mansar and Manasbal

The palynostratigraphic study of Mansar lake sediments reveals a different climatic condition as compared to that of Manasbal. These differences are attributed to the monsoon conditions. The monsoon seemed to have been largely influenced by the Pir Panjal mountain ranges.

The Mansar lake is influenced by the south-west monsoon and the variations in the sedimentation rates is attributed to the palaeomonsoonal variability. A higher rainfall results in increased runoff into the lake because of
HISTOGRAM DEPICTING REPRESENTATION OF DIFFERENT PLANT GROUPS IN THE POLLEN ASSEMBLAGE OF MANASBAL AND MANSAR LAKE SOIL PROFILES

Fig-12
which there is a higher deposition of silt and hence a higher sedimentation rate. A small rivulet on the north-west side of the lake carries the heavy monsoon rainwater which is discharged into the lake alongwith the sediments eroded during the process of denudation on this side. The south flank of the lake does not have any drainage into the lake. Due to this the rate of sedimentation is higher in MS-7 than in MS-5.

TABLE - 12

PALAEOClimATIC DATA OF THE INVESTIGATED SITES

<table>
<thead>
<tr>
<th>S.No</th>
<th>SITE</th>
<th>$^{14}$C DATES IN B.P.</th>
<th>POLLEN ZONES</th>
<th>DEPTH RANGE IN METERS</th>
<th>CLIMATIC CONDITIONS</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Manasbal</td>
<td>3,500-3350</td>
<td>a</td>
<td>5.0-4.8</td>
<td>Dry, temperate</td>
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<tr>
<td></td>
<td></td>
<td>3,350-3,200</td>
<td>b$_1$</td>
<td>4.8-4.45</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>3,200-3,100</td>
<td>b$_2$</td>
<td>4.45-4.15</td>
<td>slight warming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,100-3,000</td>
<td>b$_3$</td>
<td>4.15-3.8</td>
<td>Moist, warm temperate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,000-2,330</td>
<td>b$_4$</td>
<td>3.8-3.4</td>
<td>Moist, warm temperate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,330-2,060</td>
<td>c</td>
<td>3.5-2.3</td>
<td>Warm and moist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,330-2,620</td>
<td>d</td>
<td>2.3-1.2</td>
<td>Moist, warm temperate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,620-2,350</td>
<td>e</td>
<td>1.2-0.76</td>
<td>Warm and moist</td>
</tr>
</tbody>
</table>
The MS-7 profile is dated from modern times to 2000 B.P. while MS-5 is dated from modern times to 1500 B.P. The vegetation in the two profiles is basically the same and indicates the change of climate in that area.

Before 1800 B.P. the climate was cool and moist as is indicated by high values of conifers and low values of thermophilous plants like *Salix, Carpinus,*
Ulmus, Celtis, Juglans, Corylus and Cordia. The herbage and aquatics are also well represented.

After 1800 B.P. the climate started getting warmer which resulted in the rise of thermophilous species especially Quercus, Ulmus and Celtis and among the herbage elements Artemisia, Poaceae and Amaranthaceae/Chenopodiaceae show an increased value while there is not much change in the aquatic vegetation.

During the period between 1400 to 700 B.P. the climate was warm and this is indicated by a reduction in arboreal pollen. Conifers reduce in value. The thermophilous species are also present with low values except Quercus. Non-arboreals dominate with high values of Artemisia, Poaceae, Cerealia and Amaranthaceae/Chenopodiaceae along with stray occurrence of Asteraceae, Apiaceae and Plantago. The MS-7 profile shows a better representation of arboreal vegetation as compared to MS-5 which could be due to the presence of denser forest towards MS-7 or due to deposition of pollen from surrounding areas into the lake through the rivulet. The presence of a greater cultivation between 1300 B.P. to 700 B.P. is indicated at MS-5 by high values of Cerealia, Amaranthaceae/Chenopodiaceae, Asteraceae and Plantago. After 600 B.P. the climate showed a low degree of cooling which favoured the growth of Pinus but there was a decrease in the population of Quercus. Other thermophilous species like Ulmus, Celtis, Salix and Cordia make an appearance in MS-5 while in MS-7 these taxa become sporadic.

Again there is a difference in the profiles between 600 B.P. to 500 B.P. as a greater cultivation is indicated at MS-7 with increase in values of Cerealia, Amaranthaceae/Chenopodiaceae, Plantago, Acanthaceae, Asteraceae, Apiaceae and Brassicaceae. The top of the MS-7 profile shows a decrease in the broad leaved trees and a better representation of conifers and herbage while in the case of
MS-5 the top of the profile shows an increase in the values of broad leaved trees and *Pinus* among the conifers. The herbage show a low representation. The poor representation of herbage may suggest that cultivation was being carried out on a better scale on the northern flank of the lake as compared to its southern flank.

It may thus be inferred that the climate was cool before 1500 B.P., after that it started warming and remained warm and arid for a span of about 1000 years from 1500 B.P. to 600 B.P. In the following period the climate became humid and this warm temperate and humid phase continues up to the present.

The Manasbal lake is not influenced by the south-west monsoons due to the Pir Panjal mountain range and receives water from the locally derived clouds.

The Manasbal profile is dated from around 2000 B.P. to 3500 B.P. Around 3500 B.P. the climate was warm temperate and dry as indicated by high values of broad-leaved trees like *Quercus, Juglans, Fraxinus* and *Ulmus* and a relatively low value of conifers and aquatics.

After 3500 B.P. there was a short cool phase up to 3300 B.P. when there was a fall in the value of thermophilous plants and a rise in conifers. Moist conditions are also indicated by the rise in the values of aquatics like *Potamogeton* and *Typha*.

This was followed by a period of warm and moist climate which continued right up to 2000 B.P. and the pollen assemblage shows high values of *Quercus, Ulmus, Juglans, Betula, Celtis* and *Corylus* and relatively low values of conifers. The moist conditions were indicated by the presence of aquatics and the pteridophytes. However there were short dry spells around 3000 B.P. and 2500 B.P. Around 2600 B.P. there is an indication of cereal cultivation and it was maximum between 2330 B.P. to 2000 B.P. when the values of *Cerealita* pollen
along with *Plantago*, *Artemisia*, Amaranthaceae/Chenopodiaceae and Asteraceae are recorded highest in the soil profile.

Thus it may be inferred that between 3500 B.P. to 2000 B.P. the climate at Manasbal was generally warm temperate and moist except for small interruptions by the cool and dry phases.

**Comparison of ancient vegetational diversity with the present day conditions**

The present day vegetation of the valley is broadly divided into the following three main altitudinal zones (see Agrawal, 1992; Singh & Kachroo, 1994)

1. Mixed deciduous broad-leaved forest and conifers (1500 - 2200 m a.s.l) dominated by *Juglans, Ulmus, Populus, Cedrus, Pinus wallichiana*.
2. Conifer forest (2200 - 3200 m a.s.l) dominated by *Pinus wallichiana, Abies, Picea* along with *Prunus, Juglans, Rosa, Acer* and *Aesculus*.
3. Birch forest zone with extensive perennial herbs (above 3200 m a.s.l) dominated by *Betula, Juniperus, Rhododendron, Lonicera*, and *Syringa* associated with *Poa, Glyceria* and *Festuca*.

*Quercus, Betula, Picea, Carpinus* and *Alnus* are absent today within the valley, although some of these species may be found scarcely on the southern slopes of the Pir Panjal.

According to the above zonation the Manasbal lake which lies at an altitude of 1584 m above sea level should comprise the flora of the first zone i.e *Populus, Juglans, Ulmus, Cedrus* and *Pinus wallichiana* but the pollen diagram of the bore cores reveals the absence of *Populus* which seemingly appeared late in the present vegetation. Other elements of this zone are continuing from the former age along with a high frequency of *Abies, Picea, Betula, Quercus* and *Salix* and relatively a
low frequency of *Carpinus* and *Alnus*. Their high values also suggest that these taxa were better represented in the former ages and formed an important component of the vegetation. Their absence from the present vegetation of the valley thus indicates that there has been a climatic change.

**Agroeconomy**

The agricultural adoption at Mansar and Manasbal is evident from the record of the cereal pollen curve and a number of crop weeds like *Plantago Artemisia*, Amaranthaceae/Chenopodiaceae and Asteraceae. Based on this the following phases are recognized

1. *Period of low agricultural practice*
2. *Period of increased agricultural practice*
3. *Period of decrease in agricultural practice*

I. *Period of low agricultural practice*

As discussed above the agricultural practice had started by 3500 B.P. at Manasbal and 2000 B.P. at Mansar. This is evident by the presence of the pollen of *Cerealia* along with the pollen of *Plantago*, *Artemisia* and Poaceae. In the case of Manasbal there is a decline in the cereal pollen with the curve becoming discontinuous at the depth of about 4.6 m. This is followed by a simultaneous decline in *Artemisia* and *Plantago* and a rise in *Pinus*, *Picea* and *Cedrus*. There is another rise and fall in the cereal pollen curve and this rise and fall is also depicted by the curve of Poaceae, *Plantago*, *Artemisia* and Amaranthaceae/Chenopodiaceae. The arboreal pollen also show low values when there is an increase in the cereal pollen curve. This decline in the arboreal pollen could be attributed to clearance of forest by the Neolithic settlers for firewood or
inhabitation or cultivation. Though there is a decrease in the arboreals especially the conifers but *Quercus* shows a peak during that time. This maybe due to its prevalence above the line of conifer point.

In the case of Mansar there is a low but continuous presence of *Cerealia* along with *Plantago*, Amaranthaceae/Chenopodiaceae, Asteraceae and Apiaceae which are also represented by low values.

II. *Period of increased agricultural practice*

In the case of Manasbal the cereal curve becomes continuous from the middle of subzone - b, to the middle of zone - c though its value is low in the beginning and there is another reduction in its value at the beginning of zone - d. The pollen curves of Poaceae, Amaranthaceae/Chenopodiaceae and *Artemisia* show a correlation with the cereal pollen curve in showing a concomitant rise and fall in its value. Caryophyllaceae, Apiaceae, Asteraceae and Urticaceae are present sporadically. *Plantago* shows a continuous presence with a slight rise and fall in its value. The cereal curve attains its maximum value in zone - c. During this time *Quercus* also shows a high value. There is a decline in conifers and a slight increase in the values of *Alnus*, *Olea* and *Betula*. This could be due to increased warmth in the valley during this time.

The second rise in the cereal curve towards the top of zone - d is accompanied by a decrease in the herbage flora. Among the arboreals *Alnus* and *Quercus* decline but *Betula* and *Juglans* increase in value. Among the conifers *Pinus* shows an increase while the other conifers decline.

In the case of Mansar there is a sharp rise in the cereal curve alongwith high values of *Plantago*, Asteraceae, Acanthaceae, Apiaceae, Amaranthaceae/Chenopodiaceae and Brassicaceae in MS-7. This sharp rise is around 600-500 B.P. and the high values are present right to the top of the pollen profile i.e upto
the present times. In the case of MS-5 the high value of cereal pollen is between 1300-700 B.P. This difference in dates of cultivation is due to the different sedimentation rates at the two sites.

III. Period of decrease in agricultural practice

The cereal pollen curve of Manasbal lake shows a continuity with rise and fall in its value, yet this pollen curve does not show any indication of a decline in agriculture as the curve is without any break (hiatus) indicating that the Neolithic agronomy was well established.

The decline observed in the curve is not due to decline in agriculture but due to inversion of $^{14}$C dates as described earlier. The phase showing the maximum value of the cereal pollen in the middle of the pollen diagram is dated between 2300 B.P. to 2060 B.P. and should be positioned at the top of the pollen profile. thus indicating that the period of increased economy lies between 2600 B.P. to 2000 B.P.

In the case of Mansar lake the core MS-5 shows a decline in cereal pollen accompanied by a decrease in the values of Amaranthaceae/ Chenopodiaceae, Plantago, Asteraceae and Apiaceae. This could be due to decrease in agriculture on this flank of the lake because of its steeper slopes.

**Palaeoclimatic Survey of the Kashmir Valley**

During the last 3.5 million years the Kashmir valley has witnessed severe climatic conditions. There are a variety of data (palynological, geochemical, mineral magnetic and micromorphological analysis) on which the palaeoclimatic changes have been reconstructed (see Agrawal, 1988 and the reference quoted therein). A comparative survey of the vegetational and climatic studies carried out at 5 places in the Kashmir Valley viz. 1. Manasbal (present survey), 2. Haigam
Chronological Comparison Of Climate And Vegetation Of Six Investigated Sites In The Kashmir Valley

<table>
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<tr>
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<th>Conifer forest</th>
<th>Conifer forest</th>
<th>Conifer forest</th>
<th>Blue pine mixed deciduous forest</th>
<th>Blue pine mixed deciduous forest</th>
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</thead>
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<td>Cool temperate</td>
<td>Cool temperate</td>
<td>Cool temperate</td>
<td>Cool temperate</td>
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<tr>
<td>Butapathri</td>
<td>Barren</td>
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<td>Deciduous forest</td>
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<tr>
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<td>Warm and humid</td>
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<tr>
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<td>Warm and humid</td>
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<td>Warm temperate</td>
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<tr>
<td>Hokarsar</td>
<td>Warm temperate</td>
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<td>Cool temperate</td>
<td>Cool temperate</td>
<td>Cool temperate</td>
<td>Cool temperate</td>
</tr>
</tbody>
</table>

Fig - 13

Butapathri (Bog I) Dodia et al (1985)
Butapathri (Bog II) Dodia et al (1985)
Anchar Dodia et al (1985)
Haigam (Vishnu-Mitrre & Sharma, 1966)
Manasbal
(Vishnu-Mittre and Sharma, 1966), 3. Anchar (Dodia et al, 1985), 4. Hokarsar (Dodia et al, 1985), 5. Butaparthri Bog I (Dodia et al, 1985) and 6. Butaparthri Bog II (Dodia et al, 1985) reveal several climatic and vegetational phases (Fig. 13). The studies show occurrence of conifer wood mixed vegetation throughout the period but the values of the individual plant species show a great fluctuation in relation to climate.

Before the Holocene at around 17,000 B.P. there was a climatic amelioration (Dodia et al, 1985 Butaparthri Bog I) as indicated by the domination of C3 vegetation in the contemporary soil horizons of the valley. This was confirmed by stable isotopic data (Krishnamurthy et al, 1982). In the beginning of Holocene around 10,000 B.P. the climate was cool temperate and moist as indicated by the pollen profile of Butaparthri Bog I, zone - a and II, zone - a (Dodia et al, 1985). There was a dominance of Abies and Pinus wallichiana which formed nearly 50% of all the taxa present. The broad leaved plants eg. Juglans, Betula, Carpinus, Corylus, Ulmus, Alnus, Carya and Rhus and the herbage flora eg. Rosaceae, Poaceae, Amaranthaceae/Chenopodiaceae, Asteraceae, Artemisia, Brassicaceae, Urticaceae, Caryophyllaceae also coexisted but formed a low profile of the forest vegetation. The sporadic occurrence of aquatic vegetation indicates a low rainfall and the moist conditions which prevailed during this time could be due to the higher winter snowfall (Dodia, 1983). There was no record of cultivation during this time. The cool climate continued upto around 8000 B.P.

After this, the climate started to become warm as is indicated by a decline in the values of Pinus and Abies. The warming continued upto 5000 B.P. and the climate became less humid. This climate became more suitable for the growth of broad leaved deciduous forest in which Betula, Quercus, Corylus, Carpinus, Alnus, Juglans, Acer and Rhus dominated. The herbage comprised of Poaceae,
Amaranthaceae/Chenopodiaceae, Cyperaceae, Artemisia, Urtica. This is evident in the zone - a of the Haigam profile (Vishnu-Mittre and Sharma, 1966) and the zone - b of Butapathri Bog II profile (Dodia et al, 1985). The Butapathri Bog I profile shows a barren zone (zone - e) between 8000 to 2000 B.P. which has been attributed to warm conditions associated with heavy rains resulting in erosion and deposition of fast flowing sediments sterile in pollen (Dodia et al, 1985). There is still no evidence of cultivation at 5000 B.P. Though the warming and drying of climate had started after 8000 B.P. and was still continuing till this time but there are records of worsening of climate around 4000 B.P. at two places viz. Haigam (zone - b) and Anchar (zone - a) when there was an increase in conifers and decline in thermophilous species. The Cerealia pollen makes an appearance along with Plantago for the first time during this period but its low frequency records indicate stray cultivation. This indicates that cultivation had started in the Kashmir Valley around 4000 B.P. (Vishnu-Mitte and Sharma, 1966, Dodia et al, 1985, Butapathri Bog.11).

After 4000 B.P. the climate gradually started to become warm as there was a decline in the percentage of conifers and increase in the broad leaved species again. The conifer flora however shows regional variation resulting in the dominance of one species at one place while it declines at another place for e.g. the Haigam profile (Vishnu-Mittre and Sharma, 1966) shows a less decline of Cedrus and Picea than Pinus and Abies while in Manasbal Pinus and Picea show a greater decline than Abies and Cedrus. At Butapathri Bog. II (Dodia et al, 1985) Abies and Picea show a less decline indicating that during this time the climate was relatively cool here as compared to Manasbal and Haigam. Among the herbage Artemisia, Poaceae, Plantago and Amaranthaceae/Chenopodiaceae show a higher percentage and the aquatics show a low value indicating that around 3500 B.P. the
climate was temperate and dry and the cultivation practice was on rise. This warming of climate which started at 4000 B.P. continued upto 2000 B.P. The vegetation during this period was dominated mainly by the thermophilous species like *Quercus*, *Ulmus*, *Celtis*, *Corylus*, *Carpinus*, *Alnus*, *Salix*, *Juglans* and *Betula* which showed high values during this time. Conifers show a lower frequency than the broad leaved plants except with minor fluctuations of some genera like *Abies* and *Picea*. The aquatic vegetation which initially composed a lower percentage continuously increased towards 2000 B.P. indicating that the climate had gradually become humid.

The period between 2600 B.P. to 2000 B.P. was the period of optimal condition of climate where the *Quercus*, *Ulmus*, *Alnus* community became well established along with Poaceae, *Artemisia*, Chenopodiaceae/Amaranthaceae and *Plantago*. The conifers showed a trend of decline and the aquatics show their maximum frequency during this stage. This was the period of increased economy with maximum cultivation in the Kashmir valley. This period of increased economy is supported from the evidence of pollen profile studies made at Manasbal (zone - c), Haigam (zones d & e; Vishnu-Mittre and Sharma, 1966), Anchar (zones c, d & e; Dodia *et al*, 1985) and Butapathri Bog II (zone - b; Dodia *et al*, 1985). The *Cerealia* pollen has not been shown separately in Butapathri Bog II profile but in view of very high value of Poaceae the agricultural economy cannot be ignored.

With a sharp fall in *Cerealia* pollen frequency after 2000 B.P there appears to be declining trend of agriculture at Haigam, Manasbal and Butapathri Bog I and II but at Anchar we get high records of *Cerealia* pollen upto 1200 B.P. This may be due to shifting of agriculture activity towards this side. Hokarsar shows a different trend than the other sites. Here cultivation started during a much later
period around 1100 B.P. and this activity continued up to present times. The cereal pollen curve however shows a low range cultivation. The declining trend in agricultural activity after 2000 B.P. was mainly due to cooling of climate which also resulted in the decrease of thermophilous plant species and rise of the conifer constituent of the forest.

The full impact of this cool phase becomes more evident around 800 B.P. when there is a sharp decline in the thermophilous species and rise in conifers except in the case of Hokarsar. After this period the climate remained cool temperate as it is in the present times with domination of Pinus among the conifers and reduction in the value of Juglans, Ulmus, Salix and Betula. Quercus and Alnus are absent. Aquatics are also present indicating that the climate is cool temperate and moist. This condition is found in Haigam (zone - h), Anchar (zone - f) and Butapathri Bog I (zone - h) and II (zone - c) but in the case of Hokarsar aquatics show reduced values while Cerealita, Amaranthaceae/ Chenopodiaceae and Asteraceae show high values along with Plantago, Brassicaceae and Asteraceae which show sporadic occurrence. The climate here appears to be cool temperate but dry.

Thus it may be inferred that in the Holocene there were three major climatic phases i.e (i) the cool phase which was the starting phase. This alternated with a (ii) warmer phase and then ended up with a (iii) cool phase again. The warmer phase lasted for a period of 6000 years out of a duration of 10,000 years of Holocene. There was however an interruption of the warm phase with the cooler phase for a short period of 400 years around 4000 B.P. None the less these climatic phases show oscillations of high and low periods of warm and cool, humid, dry and moist conditions in between.
Palaeoclimatic Survey of Jammu and adjoining areas

The climate and vegetal pattern at Mansar was different than at Manasbal and other areas of Kashmir valley. The present study however reveals a broad comparison with the vegetation and climate of Manasbal which appeared around 2600 - 2000 B.P. in the nature of the conifer forest, thermophilous species of broad leaved trees and the non arboreal plants like Artemisia, Chenopodiaceae/Amaranthaceae, Poaceae, Plantago and pollen of Cereal. The climatic conditions at these two places were almost identical in being warm temperate and humid at that time but in the following period of Manasbal the climate changed and the thermophilous species declined indicating that there was change of climate, the climate becoming less warmer as is evident from the studies of palaeosoil profiles in Haigam (Vishnu-Mitre and Sharma, 1966), Anchar, Butapathri Bog I and II and Hokarsar (Dodia et al, 1985). While there appeared to be little change of climate at Mansar and the warm temperate climate continued with a little deviation thus the chronological comparison of vegetation and climate of Manasbal is not possible for want of palynological data of younger strata as it could not be procured and included in the present investigation. However, the vegetation and climate of Mansar shows a comparison with the climate and vegetation observed prevailing at Rewalsar in the Siwalik ranges of Himachal Pradesh and the Naukuchia Tal (Kamal Tal) of Kumaon. The Rewalsar vegetation (Sharma and Singh, 1974; Sharma and Chauhan, 1988) and the Naukuchia Tal (Vishnu-Mitre et al, 1967; Dodia, 1988; Sharma and Chauhan, 1988; Sharma, 1992) vegetation are comparable with the vegetation of MS-7 of Mansar in the composition of conifer and broad leaved forest as well as non arboreal species which consisted of Pinus roxburghii, Cedrus, Abies among conifers and Quercus, Alnus, Juglans, Salix, Celtis among the broad leaved forms and the Poaceae,
Chronological Comparison Of Climate And Vegetation At Jammu And Adjoining Area

- **Decline in Oak**
  - 520 Date in BP
  - Increase in Chirpine
  - Evidence of agriculture
  - *Less Warm*

- **Decline in Oak**
  - 1410 Date in BP
  - Increase in Chirpine
  - *Less Warm*

- **Oak Conifer forest**
  - 4000 Date in BP
  - *Warm*

- **Chirpine-Oak**
  - 3170 Date in BP
  - Mixed Chirpine
  - Oak forest
  - *Less Warm*

- **Mixed Oak**
  - 4140 Date in BP
  - *Warm and humid*

- **Chirpine forest**
  - 4400 Date in BP
  - *Warm and humid*

- **Naukuchia Tal**
  - (Sharma, 1992)

- **Rewalsar**
  - (Sharma & Chauhan 1988)

- **Decline in Oak**
  - 7150 Date in BP
  - Increase of Chirpine
  - Evidence of agriculture
  - *Less Cool*

- **Chirpine woods**
  - 2000 Date in BP
  - *Cool*

- **Naukuchya Tal**
  - (Dodia, 1988)

- **Mansar MS-7**

- **Mansar MS-5**

Fig - 14
Artemisia, Chenopodiaceae/Amaranthaceae among the non arboreals. The agriculture settlement at these three places seemed to have started at almost the same period about 600 B.P. (based on information given by Sharma and Singh, 1974; Sharma and Chauhan, 1988; Sharma, 1992). Vishnu-Mittre et al (1967) have also made detailed studies of the palaeosol profile of Naukuchia Tal but the 14C dates are not mentioned. A chronological comparison is given in Fig. 14.

A comparative study of Rewalsar in Himachal Pradesh (Sharma and Chauhan, 1988) dated between 4000 B.P. to present, Naukuchia Tal in Kumaon (Dodia, 1988; Sharma, 1992) dated to between 7150 B.P. to present (Dodia, 1988) and 4000 B.P. to present (Sharma, 1992) and Mansar in Jammu dated to between 2000 B.P. to present reveal that during the Holocene this region underwent climatic oscillations between increasing warmth, maximum warmth and decreasing warmth.

Around 7000 B.P. there was a domination of chirpine (Pinus roxburghii) as seen in the zone - a of the pollen profile of Naukuchia Tal (Dodia, 1988). Abies, Picea and Cedrus were also present but showed low values. The broad leaved trees like Quercus, Alnus and Ulmus also showed poor values while the non arboreals like Poaceae, Artemisia, Chenopodiaceae/Amaranthaceae and Brassicaceae showed high values indicating open woods. The climate here was slightly cooler than what prevailed later on.

Around 6000 B.P. as indicated by the profile of Naukuchia Tal (Dodia, 1988) there was a mixed chirpine (Pinus roxburghii) and oak (Quercus) forest. The other arboreal vegetation like Alnus, Betula, Juglans and Celtis were present in low values. The herbage vegetation also showed a decline in its value. The climate had become warmer during this time.
Slowly *Quercus* started increasing and around 4000 B.P. a mixed oak-chirp pine (*Quercus-Pinus roxburghii*) forest was dominating along with other broad-leaved elements like *Betula, Ulmus, Rhododendron, Juglans, Celtis, Salix, Mallotus, Emblica* and *Myrtaceae*. The climate during this time was warm temperate and humid. This was a period of maximum warmth in this region as indicated in the *zone - a* of the Rewalsar profile, *zone - a* of Naukuchia profile (Sharma, 1992) and *zone - d* of Naukuchia profile (Dodia, 1988).

After this there was an increase in conifers although *Pinus roxburghii* dominated among them. This period showed the presence of a pine-oak (*Pinus roxburghii-Quercus*) forest. There was an increase in the non arboreal vegetation. The climate was still warm and this continued up to nearly 1000 B.P. This is indicated by the profiles of Mansar in Jammu, Rewalsar in Himachal Pradesh and Naukuchia in Kumaon.

After 1000 B.P. *Quercus* started declining while *Pinus* showed high values. Among the non arboreals *Poaceae, Plantago, Artemisia, Brassicaceae* and *Amaranthaceae/Chenopodiaceae* showed higher values. The presence of *Cerealia* indicates that cultivation started around this time. Evidence of agriculture at Rewalsar (*zone - e*), Mansar MS-7 (*zone - e*) and Naukuchia (*zone - c*) (Sharma, 1992) is around 500 B.P. while at Mansar MS-5 (*zone - c*) it is much earlier dated around 1300 B.P. This could be due to slow sedimentation on this side of the lake. Due to lack of exact 14C dates of Naukuchia (Dodia, 1988) it is not possible to exactly state the dates for agricultural activity. This warm and humid climate continues up to present times.
Archaeobotanical Studies of Jammu and Kashmir

As mentioned before the Kashmir Valley was a vast lake during the Miocene and later drained out giving rise to the river Jhelum. The dried and exposed lake beds provided a settlement area for the early settlers of the Kashmir Valley.

Three archaeological sites namely Burzahom, Gufkral and Semthan have been excavated. Burzahom is a major site from where records of plant economy during Neolithic are well established. A brief account of the archaeological findings at Burzahom are discussed below.

Burzahom (District Srinagar): It reveals four occupational phases (IAR 1960-61, p.11) dated to between 4375 B.P. to 1800 B.P. The first two phases belong to the Neolithic period dated between 4325 - 3500 B.P. (Agrawal et al, 1971). Period III is Megalithic and Period IV is Early Historical.

Period I reveals the presence of pit dwellings. The early settlers dug pits and lived in areas below the ground level. Within the pits are present post-holes which suggest the presence of a wooden superstructure for roofing purposes. This is testified by the wooden material belonging mainly to *Pinus* found in the post-holes. Charred hay and birch (*Betula utilis*) was also found in the pits. Bark of birch is believed to have been extensively used for thatching the roofs. This area must have been covered with dense *Betula* forests in the past as indicated by the name of the site. The very name Burzahom indicates that it was a land of birch since in the Kashmiri language “Burza” means birch. Stone or clay hearths were found on the ground level which is indicative of an open air existence. These pit dwellings must have been used by the inhabitants to protect themselves from the cold winters. The existence of cool climate during this period is obviously
indicated by their pit dwellings. no remains of cereals have been found in Period I. The tool assemblage discovered in this period consisted of arrowheads, daggers, spearheads and harpoons (IAR 1961-62, p.17-21). The tools suggest dependence of the populace on hunting and fishing. There are also no burials to be found in Period I. The present palynological studies of soil profiles carried out from lake-bottom sediments also show low values of *Cerealia* pollen during this time, thus suggesting that agriculture had yet to become a main part of subsistence in Period I at Burzahom.

In the succeeding Period II we find appearance of mud brick habitations. A large number of post-holes were found arranged covering a large area. The evidence suggests a “community” structure (IAR 1966-67, p. 16-19). Hearths and pits were found inside the houses. The hearth showed the presence of ash and burnt clay. The burnt charcoal pieces are identified as those of *Ulmus* and *Salix*. In this period the settlers seemed to have started cultivation in this area. This is evident from reports of remains of cereal grains like wheat and barley and their wild varieties. Besides this weed seeds of *Medicago* are also found (Buth et al., 1982; Buth and Kaw, 1985). In this period stone tools of agricultural utility such as typical Neolithic polished axes, harvesters, chisels, pounders and mace heads came to light. All these evidences from Burzahom period II suggest that agriculture was becoming an important part of the Neolithic economy of early Kashmir. Similar evidence of beginning of agriculture also comes from the site of Gufkral (discussed below).

Period III is a continuation of Period II. Here, increased building activity relative to Pd. II has been noticed.

Period IV is Early Historical and according to available evidence may be dated to 3rd–4th century A.D.
Gufkral (District Pulwama): It is divided into three main cultural periods (IAR 1981-82) dated to between 3980-2790 B.P.

Period IA: Aceramic Neolithic
Period IB: Early Neolithic
Period IC: Mature Neolithic
Period II: Megalithic
Period III: Historical

Period IA: The settlement in this period consisted of dwelling pits cut into the mud. Post-holes to support structure of grass and reed were also seen around the pits. Animal remains indicate that the people were mainly dependent on wild animals and domestication was just being introduced. Grains recovered from this period are Hordeum vulgare, Triticum, Lens esculenta and a weed Lithospermum arvense (Sharma, 1982).

Period IB: Here the dwelling pits disappear and are replaced by standing structures of mud and rubble. Pottery also makes an appearance in this period. Domestication of animals like sheep, goat and cattle is seen here. The grains of the previous period are present here along with pea (Pisum arvense). Charcoal pieces indicate presence of Ulmus, Pinus and Picea.

Period IC: People during this period were well settled and practising agriculture and domestication of animals. The grains found in the above periods were also found here. Charcoal found was of Ulmus, Pinus, Picea and Buxus.

Period II: This period is associated with the arrival of menhirs and is marked by a well settled economy with people mainly dependent on agriculture and domestication. Rice (Oryza sativa) and millet (Eleusine coracana) were introduced towards the end of this period.
Period III: This is the Historical phase and marked by the appearance of iron. Grains of the previous periods are present here with a strong evidence of rice.

As the climate was getting warmer in Kashmir it was becoming favourable for agriculture and hence the establishment of the Neolithic culture as indicated in the Neolithic site of Burzahom. The warmest phase was between 2600-2000 B.P. and must have created ideal conditions for large scale agriculture to flourish. The large scale agriculture needed the introduction of farming technologies superior to the rudimentary material cultures of the Neolithic folk. In this context we find evidence of migration from outside Kashmir at the early historical site of Semthan.

Semthan (District Anantnag): It is an Early Historical site dated between 3310-1000 B.P. and is divided into five cultural periods. Archaeobotanical samples collected from the upper and middle levels do not produce any tangible result but those from the lower level (Period I) reveal the presence of charcoal pieces, carbonised grains and seeds of cultivated and wild plants (IAR 1980-81 pp. 21-23).

Wood remains reveal the presence of *Pinus wallichiana*, *Picea*, *Cedrus*, *Cupressus*, *Quercus*, *Betula*, *Juglans*, *Salix*, *Populus*, *Aesculus*, *Viburnum*, *Celtis*, *Fraxinus*, *Prunus*, *Acer*, *Morus*, *Platanus*, *Ficus* (Lone et al., 1988).

The weed seeds include *Lithospermum*, *Medicago*, *Vicia*, *Trifolium* and *Galium* species (Buth, Bisht & Gaur, 1982; Lone, 1987).

The cultivated plants include wheat, barley and rice (Buth, Bisht & Gaur, 1982; Lone, 1987).

There is no record of these grains at Burzahom but are found here right from 1500 B.C. indicating that they were introduced at Semthan from outside
Kashmir. These grains were being cultivated in the Indo-Gangetic plains and the knowledge of their cultivation was probably brought to Semthan from this region suggesting contact (Buth et al, 1982, 1985).

The evidence from Burzahom, Gujkral and Semthan gives us an idea of the vegetation that existed between 4500 to 1000 B.P. The floristic composition revealed by charcoal studies carried out by Lone et al (1988) indicate a temperate forest which is similar to the forest composition of present times. The vegetation does not seem to have undergone any major change in the last 5000 years except for changes influenced by biotic factors like man.

The present palynological studies also show a similar pattern of continuation of present vegetation for last 5000 years. The study revealed the clearance of forests for agriculture as indicated by the rise of Cerealia pollen around 4000 B.P. and the period of maximum agricultural activity between 2600-2000 B.P. The decline of Betula, Quercus, Alnus and grasses in the Kashmir valley was in all likelihood due to cutting of trees for habitation, fuel and fodder and overgrazing by animals.

There are no records of settlement before 4500 B.P. in the valley which might be due to unfavourable climatic conditions for settlement as indicated by palynological studies (see Dodia et al, 1985).

Most of the palynological studies are from lake sediments which yeild a better result from intact palynological assemblage. The inhabited sites, on the other hand, are not suitable due to disturbance of vegetation by settlers and other related factors and thus the pollen contents in the soil are poorer. In view of this, in the present study lake sites were selected. Of these Manasbal lake sediments are from a site which is nearer to Burzahom. Thus the palynoflora described from the
Manasbal lake provides an additional support to the archaeological findings at Burzahom.
POLLEN KEY

Key to the identification of isolated morphotypes from Manasbal and Mansar soil profiles

1 Pollen grains saccate
   Pollen grains non-saccate
   ... 2
   ... 5

2 Re-entrant angles present
   Re-entrant angles absent
   ... 3
   ... 4

3 Re-entrant angles poorly developed
   Re-entrant angles well developed
   ... Pinus
   ... Abies

4 Marginal crest absent
   Marginal crest well developed
   ... Picea
   ... Cedrus

5 Pollen grains united
   Pollen grains free
   ... 6
   ... 7

6 Tetrads tetragonal, loose
   Tetrads tetrahedral
   ... Typha
   ... Ericaceae

7 Grains inaperturate
   Grains aperturate
   ... 8
   ... 9

8 Exine psilate with 12-15 ridges
   Exine reticulate
   ... Ephedra
   ... Potamogeton

9 Grains porate
   Grains colpate
   ... 10
   ... 26

10 Grains with single pore
    (1-anaporate)
    Grains with more than 1 pore
    ... 11
    ... 12

11 Pore operculate, grains spheroidal
    Pore non-operculate, grains
    near shanet
    ... Poaceae
    ... Cyperaceae
<p>| | |</p>
<table>
<thead>
<tr>
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</table>
|12| Grains zoniporate  
Grains panporate  
|   |   |
|13| Pores less than four  
Pores more than four  
|   |   |
|14| Grains 2-3 zoniporate  
Grains 3 zoniporate  
|   | Moraceae  
|   |   |
|15| Pores aspdate  
Pores not aspdate  
|   | Urticaceae  
|   |   |
|16| Grains smaller in size,  
amb subcircular  
Grains larger in size,  
amb subtriangular  
|   | Corylus  
|   |   |
|17| Grains markedly aspdate.  
exine psilate  
Grains less aspdate,  
exine obscure  
|   | Betula  
|   | Carpinus  
|   |   |
|18| Grains 4-5 zoniporate,  
exine psilate  
Grains 5-6 zoniporate,  
exine reticulate  
|   | Ulmus  
|   |   |
|19| Thickened bands (arci) swing  
from pore to pore  
Archi absent  
|   | Alnus  
|   | Myriophyllum  
|   |   |
|20| Pores less than six  
Pores more than six  
|   | Taraxacum  
|   | Celtis  
|   |   |
|21| Grains spinose  
Grains not spinose  
|   |   |
|22| Exine psilate  
Exine ornamented  
|   |   |
|23| Pores aspdate  
|   | Juglans  
<p>| | |
|   |   |</p>
<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Family 1</th>
<th>Family 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Pores non-aspidate</td>
<td>Chenopodiaceae/</td>
<td>Amaranthaceae</td>
</tr>
<tr>
<td></td>
<td>Exine reticulate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exine coarsely granular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Exine tegillate, reticulate</td>
<td>Plantago</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exine non-tegillate, retibaculariate</td>
<td>Polygonum lapathifolium</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Grains simple colpate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains colporate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Grains 1 anacolpate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains 3 zonicolpate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Grains spinulose</td>
<td>Nymphaea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains retipilariate</td>
<td>Liliaceae</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Grains prolate-spheroidal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains subprolate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Exine retipilate, colpi short and broad</td>
<td>Olea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exine reticulate, colpi short and constricted</td>
<td>Fraxinus</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Exine retipilate, colpi long and crassimarginate</td>
<td>Cordia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exine scrobiculate, colpi long and broad</td>
<td>Ranunculaceae</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Grains 2 zonicolporate</td>
<td>Adhatoda</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains more than 2 zonicolporate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Grains 3 zonicolporate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grains more than 3 zonicolporate</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>34</td>
<td>Ora well defined</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ora obscure</td>
<td>35</td>
<td>41</td>
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</tbody>
</table>
35  Ora circular  
    Ora lalongate  

36  Grains prolate-spheroidal  
    Grains prolate

37  Exine granulate  
    Exine spinulate

38  Grains prolate-spheroidal  
    Grains prolate

39  Exine obscure, colpi long and thin  
    Exine psilate, colpi short and broad

40  Exine obscure-granulate, colpi long  
    Exine psilate, ora fuse to form a circular band

41  Exine psilate, colpi long and bent at equator  
    Exine retipilariate, colpi long and tenous

42  Grains 4 zonicolporate  
    Grains polycolporate