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STATUS OF VEGETATION ANALYSIS IN PAKISTAN

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ABSTRACT

History of vegetation analysis and description is discussed. Vegetation analysis in Pakistan may be divided into 5 periods *i.e.*, observational, quantitative Phytosociological, multivariate analysis (ordination), population dynamics and modern multivariate and numerical techniques. It is observed that period of observational analysis of the vegetation lasts until around 1970; however in Karachi University quantitative research was started in early sixties. The use of multivariate analysis (ordination) was initiated in 1968 in Karachi University while studies on population dynamics of forest tree species were started in 1986 from Balochistan University. Until year 2000, applying multivariate techniques to vegetation analysis were confined to the Karachi University. Now workers from various Universities are applying multivariate or numerical techniques for vegetation analysis. However still, these techniques are not as commonly used as they should be.

Keywords: Vegetation, Phytosociology, population dynamics, Species diversity, productivity, multivariate Analysis, Numerical techniques

INTRODUCTION

At the time of Pakistan's independence, there was not a single comprehensive book available on flora or vegetation of Pakistan. The only flora available was that of J.D. Hooker "Flora of British India" (1872-1897). W. Moorcroft during 1820 to 1822, V. Jacquemont during 1828 to 1832, J.F. Royale during 1832 to 1834, N. Vicary in 1838 and W. Griffith in 1847 collected vascular plants from various parts of Pakistan (see Ali, 2008). A comprehensive treatise on vascular plants was, however, published by R.R. Stewart in 1972 which formed the earlier basis of ecological studies in Pakistan. Later on, Flora of Pakistan emerged gradually since 1970 (Nasir, E. and Ali, 1970-1979, 1980-1989; Nasir Y.J. and Ali, 1989-1992 and Ali and Qaiser, 1992-2007) that gradually provided sound taxonomic ground for ecological studies in the country. So far non-vascular plants are concerned, S.R. Kashyap's flora of bryophytes was the only available flora of that time, which itself was too old - written in 1929/1932. Anand (1940, 1944) described the algal communities of Karachi coast and noted four algal belts at Manora rocky ledge.

Vegetation analysis in Pakistan may, however, be divided into five more or less overlapping periods *i.e.*, observational, quantitative Phytosociological, multivariate analysis (ordination), population dynamics and modern multivariate and numerical techniques. It is observed that period of observational analysis of the vegetation lasts until around 1970; however in Karachi University quantitative research was started in early sixties. The use of multivariate analysis (ordination) was initiated in 1968 in Karachi University while studies on population dynamics of forest tree species were started in 1986 from Balochistan University. Until year 2000, applying multivariate techniques to vegetation analysis were confined to the Karachi University. The work on functional aspects of vegetation and aboveground standing phytomass, productivity –diversity relations, and energy efficiency and cycling in grass communities, first appeared from Karachi University. Now workers from various Universities have started applying multivariate or numerical techniques for vegetation analyses. A brief description of the history of the vegetation analysis in Pakistan is described as follows.

OBSERVATIONAL STUDIES

Earlier studies on vegetation in Pakistan were observational. Schweinfurth (1957) presented the horizontal and vertical distribution of vegetation of Himalaya. In 1962/63 an assignment was given to Sir H.G. Champion to revise vegetation of Pakistan, under a Colombo plan. In 1965, he (Champion *et al* 1965) was able to present a book "Forest types of Pakistan" with the collaboration of S.K. Seth and G.M. Khattak. This was the most extensive observational work published until now and no one has been able to conduct vegetational analysis, based on the entire country. Schickhoff (1995) provided historical dimension of forest cover changes in Kaghan valley. He reported through vegetation mapping that about 50% of the forests have disappeared. Alan (1987) assessed the impact of 3, 500,000

Afghan refugees on the vegetation and environment of Pakistan's Hindukush-Himalaya. Siddiqui *et.al* (1999) adjudged the climate change impact on biomes of forest ecosystem of Pakistan to be negative. Out of nine biomes, three biomes are shown to be reduced in future and five biomes to increase in size, 1990 being the base line year and climate change being in form of 0.3 ^{o}C rise in temperature and precipitation change as 0, +1 and -1 % decade^{-1}.

Before and after Champion various workers *i.e.*, Chaudhri (1952, 1953, 1960); Khan (1955, 1960); Khan and Repp (1961); Repp and Khan (1959, 1960), Beg (1974) made observations on the vegetation of Baraland of Punjab, Sheikhupura, Kaghan; Tropical thorn and Salt range forest; riverian forests; Tharparkar, Isplingi valley and Chitral, respectively. Rutter and Shaikh (1962) surveyed the vegetation of wastelands around Lahore and described its relations with soil conditions. Nasir and Webster (1965); Repp and Beg (1966), and Hussain (1969) conducted vegetational survey of Nagarparker; Hushe valley; Ziarat and Ayub National Park, respectively. Vegetation types of Balochistan and Quetta-Kalat region were described by Rafi (1965, 1973), while Naqvi (1974-1976) and Hussain *et al* (1980) observed vegetation of Peshawar, Khyber Pass, Murree, Hazara and Mardan. Shah *et.al*. (1964) described soil-vegetation relationships of some districts of West Pakistan. The above workers with many others have contributed a basic knowledge about the area, flora and vegetation of various parts of Pakistan, however their work lack quantification and statistical analysis. Saifullah and Rasool (2002) described mangroves of Miani Hor lagoon and only three species of mangroves, of which *Avicennia marina* and *Rhizophora mucronata* were reported to be dominant. Rasool and Shaukat (2005) described biological spectrum of the Astola island, in south of Pasni in the Northern Arabian sea. Khan and Gul (2002) described the halophytes in Sabkhat of Pakistan coast and Khan (2003) presented an overview on ecology of halophytes of Pakistan. Gorsi (2003) Studied vegetation of rock crevices of Muzaffarabad, mainly composed of small herbs, shrubs, soil-binding grasses and ferns. Mycorrhizal status of 14 species is also reported from various locations.

QUANTITATIVE STUDIES

Quantitative studies (without multivariate analysis of vegetation)

In Pakistan, quantitative work on vegetation was started by D.M. Currie, deputed by FAO under the Arid Zone Development Scheme. Monsi from UNESCO was able to show quantitative variation in floristic composition among various selected locations of Pakistan. Monsi and Khan (1960) presented natural vegetation of Thal and compared it with the vegetation of other areas of Pakistan. This was the start of 2nd period of vegetation analysis when interest was shifted to quantitative approach in Pakistan.

Under the supervision of Late Dr. Syed Abdul Qadir Junaidi (pioneer and prominent Phytosociologist / Ecologist of Pakistan), extensive phytosociological works were carried out in various places of Sindh, Balochistan, Northern areas and other places of Pakistan. Chaudhri and Qadir (1958), Chaudhri (1961), Ahmed (1964), Qadir *et al* (1966), Qureshi and Ahmed (1966), Shaukat (1968), Hamidul (1970), Karim (1970), Shaukat and Hussain (1970), Wasiullah (1972), Iqbal (1972), Ahmed (1973), performed phytosociological analysis at Karachi University, calcareous Hills around Karachi, riverain forest of Larkana, coastal sand dunes, coastal swamp, Khade-Ji-Fall area, waterlogged and saline area of Gharo to Thatta, Mirpur Sakro, Ghulamullah to Sujawal, Manghopir Industrial area and Industrial areas of Dhabejee, Gharo and Manghopir, respectively. Chaudhri *et.al*. (1966) described five types of vegetation in riverian tract of Indus around Ghulam Mohammad Barrage namely *Tamarix-Saccharum* association, *Acacia Arabica* association, *Salvadora persica* association, Pond association, and *Salvadora-Prosopis* association. Shaikh and Irshad (1980) investigated effects of wastewater effluents from tannery on vegetation and soil in Lahore.

In Balochistan Province, Khan and Hussain (1963) conducted ecological assessment of Hazarganji forest while Khilji (1982), Nisar (1982), Majeed (1984) carried out phytosociological investigations around Quetta valley and Hazarganji National Park. Snead and Tasnif (1966) described vegetation types in Lasbella region of Pakistan and Kayani and Shaikh (1981) presented Phytosociological data on inter-relationships vegetation, soil and termites in Arid Marine Tropical Coastlands of Pakistan. Kayani *et al* (1984, 1988), Qadir and Fawaris (1986), Qadir and Ahmed (1989), performed phytosociological studies in Wetlands of Quetta / Peshin District, Nisarabad – Sibi District, Sabka of Zuara and Hazarganji forest respectively. Similar work was presented by Tareen and Qadir (1990, 1987, 1991, 1993, 2000) in Quetta District, Sinjwani to Duki and Harnai regions. Tareen *et al* (1992) also quantitatively analyzed vegetation of Zarghum area of Quetta Division. In Balochistan, first extensive phytosociological survey of Juniper and pine forests was carried out by Moinuddin Ahmed and his students of Balochistan University. This was the beginning of 3rd era in vegetation analysis in Pakistan. Beside phytosociology, structure and dynamics of planted tree species of Quetta (Ahmed 1988), in *Juniperus excelsa* forests of Juniper track and surrounding areas (Ahmed *et al* 1989, 1990) and in *Pinus gerardiana* forests of Zhob District (Ahmed *et al* 1991) were discussed. In these investigations, modern dendrochronological methods were applied for the first time in the country (Ahmed and Sarangzai, 1991). These studies were the mile stone of forest population dynamics investigations in Pakistan. However, unfortunately from 1991 to year 2005, no one presented any substantial work on dynamics of individual forest tree species.

Vegetation and flora of Hushee valley was presented by Nasir and Webster (1965). In Northern areas of Pakistan, first extensive quantitative phytosociological work was carried out by Moinuddin Ahmed and his team (1976a, 1976b, 1986, 1988), during the first scientific expedition of northern areas under Govt. of Pakistan Planning Commission, Pakistan Science Foundation and NDVP (National Development Volunteer Programme). The team spent six months in the area and was able to sample vegetation, conducted soil analysis along the road from Chilas to Gilgit and Astore, Gilgit to Nalter, Skardu, Phunder and Hunza. Altitudinal distribution of grasses, sedges and rushes of Deosai plateau was presented by Sultan *et al* (2007).

A great deal of quantitative work has been conducted by Farrukh Hussain and his team from Peshawar University in Pukhtoon Khwah Province (former N.W.F.P). They carried out quantitative studies in wet and waterlogged areas of Mardan (Hussain *et al* 1980), saline areas of Peshawar (Hussain *et. al.*, 1981), Karamara Hill, Mardan (Hussain Tojal Malook 1984), District Swabi (Hussain and Khan 1989), Docut Hill during spring (Hussain and Shah 1989), Docut Hills during winter (Hussain and Shah, 1991), Docut Hills in spring and tropical dry deciduous forests of Swabi. (Hussain *et. al.*, 1992, 1993). "Ecology and vegetation of Lesser Himalayas of Pakistan" containing some quantitative information about vegetation of different areas was also presented by Farrukh Hussain and Ihsan Ilahi (Hussain and Ilahi, 1991). This book is a good addition of Pakistani writers for the students of ecology in Pakistan.

Tojal Malook and Naqvi (1982) and Ilahi *et al* (1989) studied vegetation of Kamarar Hills, Mardan and Nizampur Hills, Attock. Hussain *et al* (1989) and Malik and Hussain (1987) investigated vegetation of saline and waterlogged area of Hazro and vegetation around Muzaffarabad. The vegetation structure of Pirghar Hills of South Waziristan and Girbanr Hills of Swat was analyzed by Hussain and Badshah (1998) and Hussain *et al* (1995) respectively. In this province, Chaghtai and Yousuf (1976), Chaghtai and Shah (1978), Chaghtai *et al* (1978, 1983, 1984, 1988, 1989), studied vegetation of Kohat, grave yards of Peshawar, graveyard of Kohat, around shrine of Ghalibgul Baba, upland forest of Nowshera, and Hazara. Wildlife habitats of Pakistan, future and communities of oak forest of Swat was presented by Beg (1975), Beg and Khan (1980, 1984).

Hussain (1964) conducted ecological survey of the vegetation of Nagarparker and Hussain (1969b), Naqvi (1976) did phytosociological survey at Wah Garden and Murree Hazara Hills, respectively. Amin and Ashfaque (1982) followed some study at Ayub National Park. A Phytogeographical analysis of the phanerogams of Pakistan and Kashmir was conducted by Ali and Qaisar (1986). Phytosociological studies in Azad Kashmir, around Muzaffarabad and Kotli Hills were carried out by Malik and Hussain (1987, 1990). Vegetation analysis of Sundangali, Chimer Hills and Samani Hills were presented by Malik *et al* (1990), Ahmed (1991) and Malik *et al* (1994). Khan and Ahmad (1994) prepared floristics, life-form, leaf-size and halo-physiotypic spectra of Pakistan coastal vegetation. Two hundred thirty species excluding mangroves (182 dicotyledons + 49 monocotyledons + 1 gymnosperm) associated with 51 families and 152 genera. Several species were the new records. Life-form relations to physiotypes and salinity relations of physiotypes in specified segment of classified soil salinity gradient and along the gradient were described. Mahmood *et.al.* (1994) analyzed soil-vegetation relationships and successional change in the saline a wasteland of Lahore. Iqbal *et.al* (1998) recognized six plant communities along Lyari River in Karachi and described edaphic relations of them including heavy metals like Zn, Pb and Cu. Phytosociological analysis of the vegetation of Dao Hills, Kotli Hills and comparative study of Ganga Chotti and Bedori Hills was presented by Malik *et al* (2001), Malik and Malik (2004) and Malik (2005). Ahmad *et. al.* (2008) described the vegetation of Kufri (soone valley) on the basis of density and frequency. Choudhary *et. al.* (2001) conducted phytosociological studies in Chhumbi Surla wildlife sanctuary of Chakwal, Pakistan, on the basis of importance values of the species. Choudhry *et. al.* (2005) described floristic composition, community structure and arbuscular mycorrhizal fungi in association with vegetation of Cholistan desert. Sher and khan (2007) described floristic and life form spectrum of Chagharzai valley of Buner District. Ullah *et.al.* (2007) presented data on cover and composition of Pabbi hills Kharian range of Gujrat. Badshah *et. al*. (2010) described some parameters of vegetation structure (life form, leaf size, and importance values of constituent species besides some data on soil characteristic as well).

STUDIES ON POPULATION AND VEGETATION DYNAMICS

Shaukat *et. al* (1981a) described vegetation dynamics on calcarious hills around Karachi. The phytosociological pattern of variation was in accordance with Climax pattern hypothesis of R.H. Whittaker. The major reactions of the plants to the edaphic characteristics during various seral stages involved progressive decrease in soil pH and $CaCO_3$ coupled with increase in soil depth, gradual increase in organic matter (humus) and finer soil components resulting in the improvement of moisture regime.

Population dynamics of some pine forests of Afghanistan was investigated by Mohammad Wahab (Wahab *et al*, 2008). This was the first study of this kind from Afghanistan. Ahmed *et al* (2010 a, b) conducted population studies on *Cedrus deodara* forests, by Ahmed and Naqvi (2005) in *Picea smithiana* forests, Ahmed *et al* (2006) in Himalayan forests of different climatic zones, by Siddiqui *et al* (2009) in *Pinus roxburghii* forests and by Ahmed *et al* (2009) in *Olea ferruginea* forests of various parts of Pakistan. In addition, Siddiqui (2010) was involved describing vegetation, structure and dynamics of moist temperate forests while Wahab (2010) and Khan (2010) conducted similar investigation in Dir and Chitral areas. However, vegetation of Chitral Gol and dry oak forests zone was presented by Beg (1974) and Beg and Khan (1980). Though mangrove ecosystem was described by Saifullah (1982), its phytosociology, structure and dynamics was presented in detail by Saifullah and Shaukat (1993) and Nazim (2010).

In 1990, Khan and Shaukat, proposed a canonical-correlation-based technique (CANCOR) for the detection of intraspecific competition in pure plant populations. Spatial and size class patterns an old population of *Arthrocnemum indicum*, (Willd.) Moq. were then investigated by Khan *et.al.* (1993) and neigbourhood interactions among *Arthrocnemum indicum* individuals were detected by using CANCOR analysis. Khan and Shaukat (1996) extended application of CANCOR for detection of competition in a pure tree population of *Avicennia marina* (Forssk.) Vierh. At Rehri island mangroves and successfully explained the competitive interaction among the plants of various age. Khan and Shaukat (1997) again checked the workability of this technique in detecting intraspecific competition in an uneven aged pure population of a coastal grass *Urochondra setulosa* exhibiting phasic development of growth in the halo-xeric environment of Hawkes Bay, Karachi. Khan and Shaukat (2000) described site and density regulated plasticity and size hierarchies in populations of an annual herb, *Gynandropsis gynandra* (L.) Briq. Khan (2003) investigated population structure, edaphic relations, interplant spacing, and neighbours interaction in field population of a halophytic herb of Karachi, *Limonium stocksii* (Boiss.) Kuntze.

STUDIES ON SPECIES DIVERSITY (METHODOLOGICAL AND VEGETATION DIVERSITY)

Shaukat *et. al.* (1978) described relationship amongst dominance, diversity and community maturity in desert vegetation. Shaukat and Khan (1979) conducted a comparative study of statistical behaviour of diversity and equitability indices with respect to the desert vegetation. Shaukat *et. al.* (1981a) published variation with the progression of the vegetation on calcarious hills around Karachi and Shaukat *et. al* (1981b) published detailed results of their studies with respect to the applicability of McIntosh's diversity measures and analyzed diversity relations with respect to the compositional Phytosociological gradients of desert vegetation conceived through ordination. Saifullah *et.al.* (1984) described diversity of seaweeds of Karachi and presented curvilinear relationship between diversity and biomass of seaweeds. Diversity relations to the edaphic peculiarities of 35 coastal perennial plant community types were described by Khan (1987). Khan *et. al*. (2003) described halo-physiotypic peculiarities, relative abundance pattern of species, and edaphic relations of diversity in inland perennial communities of waterlogged very highly saline halo-catena of District Hyderabad, Sindh.

FUNCTIONAL STUDIES (ABOVEGROUND PHYTOMASS, PRODUCTIVITY AND PRODUCTIVITY-DIVERSITY RELATIONS)

There is a great deal of paucity of data on functional characteristics of natural plant communities of Pakistan. Some data on vegetation and phytomass dynamics of some grass dominated communities of Karachi and the Pakistan coast have been published by Khan *et al.* (1989, 1999, 2000, 2001, 2002, 2005 a and b, 2006b) and Khan (2009). Khan *et. al.* (1989) presented data on structure and aboveground standing biomass of 12 grazable grass communities of Pakistan coast. Khan *et al.* (2001) described temporal variation in structure, diversity and phytomass of an old *Dichanthium annulatum* community in the Karachi University campus. In 2002, Khan and co-workers presented data on summer and winter aspects of phytomass and density variations in five grass community types viz. *Chrysopogon aucherii, Desmostachya bipinnata, Sporobolus arabicus, Sporobolus halvolus*, and *Urochondra setulosa* communities. Khan *et. al.* (1999, 2005) described data on life form composition, relative abundance pattern of species, their density and biomass for summer and winter aspects of grass dominated communities of Karachi. The community delineation was made through biomass- based compositional similarities. Hussain and Durrani (2007) described forage productivity in Harboi rangeland (Kalat) and estimated biomass around 10772.5 kg/Ha/year predominated by shrubs (81.3%), followed by grasses (11.8%) and herbs (6.9%).

Seasonal density- and biomass-based variation in structure, diversity, net above and belowground primary productivity, system transfer functions, energy efficiency and energy cycling have been presented for *Lasiurus-Cenchrus* community of dry sandy habitat by Khan *et. al.* (2000), *Dichanthium annulatum* community in non-saline

coastal depression of Karachi (Khan *et. al.,* 2005) *Lasuirus–Cenchrus* community in semi-moist habitat (Khan *et. al.,* 2006b) and *Cenchrus* community in moist saline habitat (Khan, 2009). Agha (2009) presented seasonal productivity data in a coastal population of *Cressa cretica* - with higher net primary productivity and Aboveground biomass during winter in comparison to summer. Belowground biomass was lower than aboveground biomass.

Omer *et. al.* (2006) described seasonal changes in pasture biomass, production and offtake under transhumance system in Northern Pakistan and gave some valuable recommendation with respect to the utilization of alpine and dry temperate pastures.

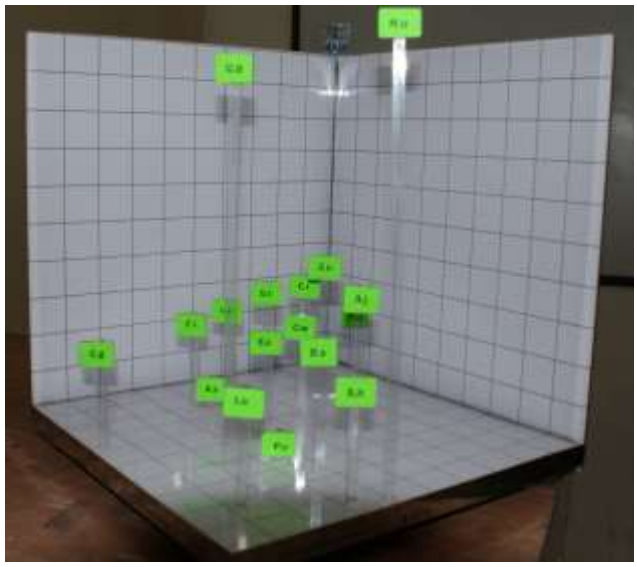
MULTIVARIATE STUDIES

In the subcontinent multivariate analysis of vegetation was initiated by Syed Shahid Shaukat (Shaukat, 1968, Shaukat and Qadir 1971), from Karachi University, presenting an indirect gradient analysis of the vegetation of calcareous Hills around Karachi. This was the turning point and milestone in quantitative vegetational analysis in Pakistan. He was followed by Moinuddin Ahmed (Ahmed 1973 and Ahmed *et al* 1978) who described vegetation environmental complex of some industrial areas of Sindh, using stand (indirect gradient analysis), species and environmental ordination (direct gradient analysis) techniques. He also presented first multivariate analysis of the vegetation around Skardu, northern areas Ahmed (1976) and Chilton in Balochistan (Ahmed, 1987). Khan (1980) used the ordination technique to study behviour of important constituent species of some desert and semi-desert vegetation stands predominated separately by *Achyranthes aspera, Persitrophe bicalyculata, Cassia holosericea,* and *Prosopis juliflora* in and around Karachi. Shaukat *et al* (1980), Iqbal *et al* (1983) and Hussain *et al* (1994) used this technique on the vegetation of Gadap area, around polluted channels of industrial areas of Karachi and tropical dry deciduous forest of Swabi, Mardan, respectively. Shaukat *et. al.* (1981a) performed ordination of shrub and tree species of calcarious hills of Karachi and diversity relations of various seral vegetations with the edaphic environment. Khan and Shaukat (1987), Shaukat and Uddin (1989a and b) used multivariate analysis to describe composition and pattern of *Achyranthes aspera* dominated communities. A phytosociological investigation was carried out for coastal areas of Sindh and Balochistan by Khan (1987) who identified 35 perennial plant community types on the basis of agglomerative cluster analysis. Shaukat (1994) carried out multivariate analysis of the niches and guild structure of desert plant populations. Dasti and Agnew (1994) analyzed vegetation of Cholistan and Thal deserts of Pakistan by ordination and classificatory techniques. The extracted units of vegetation were related to topography, disturbance and utilization by humans. Awan *et al* (2001), Ali *et al* (2004), Khan and Shaukat (2005) used cluster analysis for vegetation of Swat, multivariate analysis in some industrial areas of Punjab and grass dominated communities of Karachi (winter aspect), respectively. Khan *et. al.* (1999) published the account of structure, composition and classification of grazable grass dominated communities of Karachi in summer aspect on the basis of cluster analysis. The merit of this work was that community delineation was performed on the basis of biomass-based compositional similarities among the stands. Winter aspect of this vegetation (Khan and Shaukat, 2005) was studied with multivariate analysis on the basis of biomass of constituent species as the basis of compositional similarity among the species. Khan *et. al.* (2003) used agglomerative cluster analysis to delineate halophytic vegetation into communities and identified five communities in highly salinized waterlogged areas of Hyderabad district, Sindh. Khan *et. al.,* (2006a) recognized directions of edaphic variation in the above halo-catena through principal components analysis and presented behaviour of the characteristic species along the environmental gradients and the distribution of Breckle's halo-physiotypes in this inland halo-catena. The vegetation-environment relationship of Kirthar National Park, calcareous Hills around Karachi, Lobibehr forest (Pindi), Himalayan foot Hill vegetation and Pothowar plateau of Pakistan were analyzed by Enright *et al* (2005),

Shaukat *et al* (2005) and Malik and Hussain (2006, 2007), Dasti *et al* (2007) using these techniques. Peer *et.al.* (2007) investigated grazed vegetation of eastern Hindu Kush Mountains located at a transition zone between the winter-rain influenced Irano-Turanian regions in the West and arid central Asian regions in the North, and monsoon influenced Sino-Himalayan regions in the southeast. They identified eleven plant communities in the region linked to four vegetation types through TWINSPAN and CCA. Wazir *et al* (2008), Sheikh *et al* (2009) and Jabeen and Ahmed (2009) applied multivariate analysis to investigate vegetation of Chapursan valley, Havalian and Ayub National Park. Fakhar-i-Abbas (2009) described eight plant communities on the basis of TWINSPAN analysis in the range of Grey Goral in Pakistan and Azad Kashmir. Ahmed *et.al.* (2009) Evaluated ecological aspects of road-side vegetation around Havelian using multivariate techniques of DCA and CCA. Ahmed et.al. (2009) performed ordination and classification of herbaceous vegetation of Margalla hills, Islamabad, Pakistan through and described four vegetation groups through TWINSPAN analysis. They also performed DCA analysis. Ahmed *et. al.* (2010) conducted a survey of vegetation along Motor way (M-2) and analyzed the vegetation with TWINSPAN and DECORANA identifying two major communities divided into 16 sub-communities.

Due to unavailability of computer facilities and limited knowledge of these techniques, only a few ecologists were interested in these techniques. Therefore, for a long time application of multivariate analysis were confined to Karachi University *i-e.,* Syed Shahid Shaukat and his students. His team used these techniques not only for vegetation analysis, but also to investigate competition and Siddiqui (2003) applied cluster analysis to classify botanical strains of *Pseudomonas* in the context of plant pathology.

In the present workshop, the vegetation of Gharo and Dhabeji was studied by the participants. The data was processed for ordination using Bray and Curtis technique. Figure 1 illustrates the species ordination diagram, the result of this exercise.



Three-dimensional species ordination model constructed during 2nd National Conference / Workshop on Ecology (Ahmed and Shaukat, 2010)

Fig. 1. Species ordination of Gharo-Dhabeji vegetation on the basis of Bary and Curtis technique. Lecture Notes of Workshop on Ecology (2010).

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