# Assessment of land suitability for coconut cultivation in southern Karnataka, India

**Abstract**: The assessment of land suitability for a specific use is a vital part of land use planning and agricultural development. The basic feature of land suitability evaluation is the comparison of the requirement of land uses with resources offered by the land. A study was conducted to evaluate the land suitability for coconut cultivation in southern Karnataka with a prime focus on increasing the productivity of coconut by way of promoting its cultivation in areas which show high and moderate suitability, and restricting at marginally suitable areas.For this seven soil pedons were selected on the map of coconut-growing areas, delineated with the help of land resource map and report of Karnataka state, generated at 1: 2,50,000 scale by ICAR-NBSS & LUP, Bangalore and were located at Krishnarajapete, Arasikere, Beltangadi, Brahmavara, Hosadurga, Turuvekere and Gubbi representing the density of coconut-growing areas in different agro-climatic zones.Land suitability was evaluated following FAO (1976) guidelines. Land suitability assessment of major coconut-growing areas of southern Karnataka indicated thatKrishnarajapete and Arasikere have moderately suitable lands with moderate limitations while others have marginally suitable lands with severe limitations for coconut cultivation.

**Keywords:** Coconut cultivation**,** Pedon, Land suitability classification, Climatic and Site characteristics and Soil fertility.



## Introduction:

"Coconut palm occupies a unique position in the socio-economic structure of the country. The economic importance is quite evident from the fact that it is grown in more than 90 countries of the world. In India, it is grown in seventeen states and three union territories mostly along the coastal regions of the country. Recent estimates indicated that in the world coconut is grown in an area of about 11.97 m ha and India ranks third in area and production, with Indonesia and Philippines ranking first and second respectively"(APCC, 2017). "In India, the crop is grown in an area of about 2 million ha with an annual production of about 20425.6 million nuts. India is the fourth largest exporter of value added products of coconut in world after Philippines, Indonesia and Srilanka and earns revenue of 2077 crores annually from it"(APCC, 2017). "Karnataka occupies 2$^{nd}$ position both in area under cultivation and production after Kerala and Tamil Nadu respectively,with a monopoly of desiccated coconut industry and tender coconuts in the country" (CDB, 2017)."The palm is amenable to both plantation and homestead management and it can be either a major crop or a minor one in a homestead garden of mixed crops. While responding favourably to scientific management, the palm also tolerates negligent farming to a

certain extent. Thus, it can adapt to the divergent farming situations and management practices that are prevalent in different agro-climatic regions.The coconut palm is not very fastidious in its climatic requirements. In fact it is highly adaptable to a variety of environmental conditions, but is considered essentially a tropical plant. It requires an equatorial climate with high humidity. Coconut can withstand semi-arid to humid climate with mean annual temperature approximately 29ºC, less than 3 dry months and rainfall of 1000-3800 mm.The best soil for coconut needs to be deep, friable, well-drained, non-saline, non-sodic, non-flooding, neutral light to well structured heavier soil.Coconut does well on alluvial and sandy soils near the coast" (Sys *et al.*, 1993).

In Karnataka, coconut is being grown in an area of 5.15 lakh ha with production and productivity of 5141.2 million nuts and 9982 nuts per ha, respectively (CDB, 2017), thus contributing major share in coconut industry in the country.

"Land suitability evaluation is the process of assessing the suitability (or potentiality) of land for a specific use" (Sehgal, 1996). It is the subsequent step following the soil resource mapping process. It involves the interpretation of basic data on climate, soil, vegetation and qualities of land. The basic feature of it is the comparision of the requirement of land uses with the resources offered by the land. Assessing the suitability of land for specified purposes is increasingly being recognized as an essential part of land use planning and agricultural development. Various range of techniques and types of approaches are currently available for suitability evaluationforexample US land capability classification (Klingbiel and Montgomery, 1961), the British land use capability classification (Bibby and Mackney, 1969), the FAO Framework for land evaluation (FAO 1976), a French numerical system (Begon et al.,1978), rapid rural appraisal (Chambers and Carruthers 1981), soil potential ratings (McCormack and Stocking, 1986). Among these various approaches the techniques developed by FAO framework for land evaluation (FAO 1976) is most widely used because itprovides a good basis for determining physical land suitability and for extendingthe information base into yield potential for different management levels and farming systems (James Ngowi and Michael Stocking,1989).

The present study was undertaken to evaluate the soils and climatic conditions of major coconut-growing areas for their suitability to identify potential areas. Based on the suitability assessment, Turuvekere and Gubbi in Tumkur, Arasikere in Hassan, Krishnarajapete in Mandya, Hosadurga in Chitradurga, Brahmavara in Udupi and Beltangadi in Dakshina Kannada districts were identified as the most potential areas for coconut cultivation .

## Material and Methods

The study area includes Gubbi and Turuvekere in Tumkur (Eastern Dry Zone), Arasikere in Hassan (Southern Transition Zone), Hosadurga in Chitradurga (Central Dry Zone), Krishnarajapete in Mandya (Southern Dry Zone), Beltangadi in Dakshina Kannada and Brahmavara in Udupi (Coastal Zone).Extensive field traversing of the area was done.

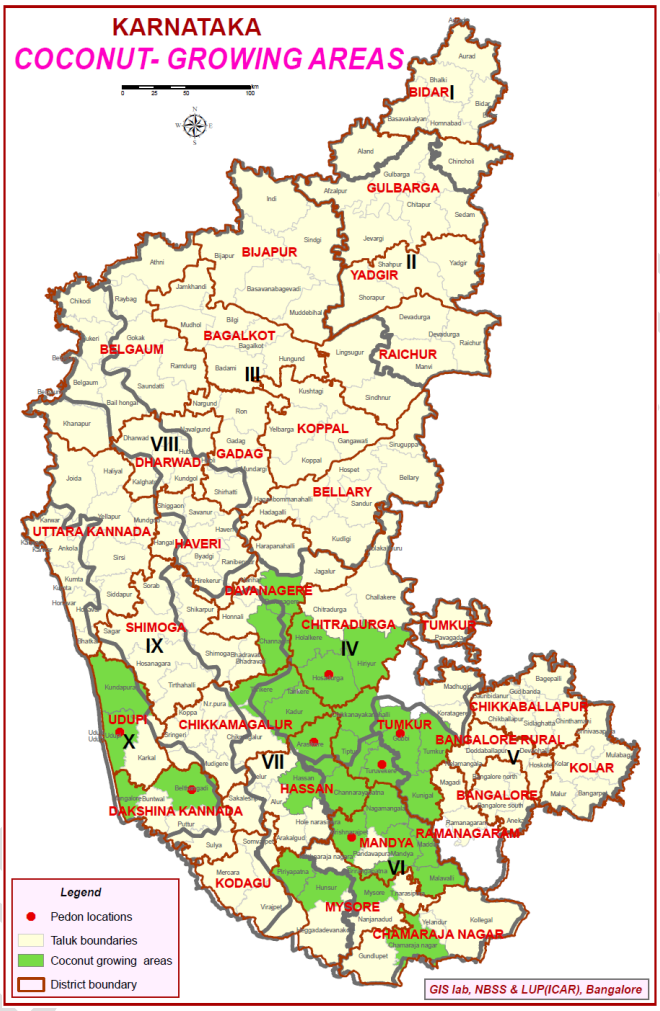


**Fig. 1. Major coconut-growing areas of Karnataka**

"On the basis of variability in site characteristics and productivity of coconut, seven soil pedons were studied to assess the land quality at different locations. Horizon-wise soil samples were collected from all the pedons for the analysis of physical and chemical properties. Morphological properties of the soils were studied as per the procedure outlined in Soil Survey Manual (Soil Survey Staff,2014).Particle-size analyses were done by International Pipette method" (Sarma *et al*., 1987). "The pH was determined in 1: 2.5 soil-water suspension and electrical conductivity in its supernatant portion" (Jackson, 1973). The wet digestion method (Walkley and Black, 1934) was followed to determine the organic

carbon (OC) content.Cation exchange capacity of the soils was determined by the ammonium acetate leaching method (Sarma *et al.,* 1987).Climatic data recorded by Indian Meteorological Department for Karnataka from 1966 to 2002 was used in the present study.Land suitability was evaluated following FAO (1976) guidelines. It involved formulation of climate and soil requirements of the crop and rating of these parameters viz. highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N).

**Results and Discussion**:

The weighted mean of soil physical and chemical properties was determined for the suitability assessment of coconut growing areas. As per the Sys method (modified by Naidu *et al.,* 2006) the landscape and mean values of soil properties were compared with the requirements of coconut crop (Table 1). Coconut adapts to a wide range of climatic conditions, however, it is well adapted in the areas with optimum temperature of 25 to 30 $^{0}$C, annual rainfall of 1400 to 3000 mm and dry month of less than 4 months (Naidu *et al*., 2006). Coconut prefers well drained, sandy clay loam to sandy clay soils. Soils with depth of 100 to 150 cm supports the crop satisfactorily. Coconut performs well on sites with none to slight soil erosion hazard. It can adapt to varied soil pH range from moderately acidic to moderately alkaline. The organic carbon percentage of more than 0.75 is ideal for coconut cultivation. Climatic, site, soil and fertility characteristics of major coconut-growing areas of southern Karnataka are tabulated (table2) to evaluate land suitability for coconut cultivation. In Krishnarajapete area moderate limitations for climatic requirements (mean annual temperature, rainfall, prolonged dry period), site (elevation and erosion) and soil fertility characteristics like cation exchange capacity was existed. Arasikere exhibited moderate limitations for climatic requirements (mean annual temperature, rainfall, prolonged dry period), site characteristics (erosion) and soil fertility characteristics like pH, cation exchange capacity (CEC), base saturation and organic carbon. Beltangadi had marginal limitations for site characteristics like slope and fertility characteristics like CEC where as Brahmavara had marginal limitations for climatic requirements in terms of prolonged dry period, soil characteristics like more gravels and fertility characteristics like CEC. Marginal limitations for climatic requirements like annual rainfall and prolonged dry period, soil characteristics like clayey texture (swell-shrink type) was seen in Hosadurga.Turuvekere and Gubbi had marginal limitation for prolonged dry period.According to the criteria given by FAO (1976), ratings were assigned to each characteristic for each area (table 3).

**Table 1: Land suitability criteria for coconut cultivation**

| | Ideal (S0) | Highly suitable (S1) | Moderately suitable (S2) | Marginally suitable (S3) | Notsuitable (N) |
|---|---|---|---|---|---|
| **Climatic requirements** | | | | | |
| Mean annual temperature (ºC) | 27-28 | 25-30 | 22-25 and 30-32 | 18-22 and 32-36 | <18 and >36 |
| Annual rainfall (mm) | 1750-2250 | 1400-3000 | 700-1400 and >3000 | 500-700 | <500 |
| Dry month (<50 mm) | < 2 | 0-4 | 4-5.5 | 5.5-7 | >7 |
| Relative humidity (%) | 80-95 | 60-95 | 40-60 and >95 | 30-40 | < 30 |
| PET (mm) | 1500-1700 | 1300-1800 | 800-1300; 1800-2000 | 600-800; 2000-2200 | <600; >2200 |
| **Site characteristics** | | | | | |
| Elevation (m) | <500 | <800 | 800-900 | 900-1200 | >1200 |
| Slope (%) | <3 | <8 | 8-15 | 15-30 | >30 |
| Drainage | Well | Well | Moderately well; Some what excessive | Imperfectly drained; Excessive | Poorly drained |
| Depth of water table (m) | >10 | >5 | 2-5 | 1.0-2.0 | <1 |
| Erosion hazard | None to very slight | None to slight | Moderate | Severe | Very severe |
| **Soil characteristics** | | | | | |
| Depth (cm) | >150 | >100 | 75-100 | 50-75 | <50 |
| Texture | scl | cl, sil, sc, sicl | sl, c, sic | ls, s, si,c (swell - shrink) | - |
| Gravel (%) in the soil control section (25-100 cm) | <15 | <35 | 35-60 | 60-80 | >80 |
| **Soil fertility (0-25cm)** | | | | | |
| pH | 6.5-7.3 | 5.5-7.9 | 4.5-5.5 and 7.9-8.4 | 4.0-4.5 and 8.4-9.0 | < 4.0 and>9.0 |
| CEC (cmol(p+)$kg^{-1}$) | >24 | >16 | <16 | - | - |
| Base saturation (%) | 60-80 | 35-90 | 25-35; >90 | 10-25 | <10 |
| Organic carbon (%) | >0.75 | > 0.50 | 0.2-0.5 | <0.2 | - |

(Modified from Naidu *et al.*, 2006)

**Table 2: Climatic, site, soil and fertility characteristics of major coconut-growing areas of southern Karnataka.**

| Parameters | Krishnarajapete | Arasikere | Beltangadi | Brahmavara | Hosadurga | Turuvekere | Gubbi |
|---|---|---|---|---|---|---|---|
| **Climatic requirements** | | | | | | | |
| Mean annual temperature (˚C) | 24.7 | 23.6 | 27.4 | 27.2 | 25.6 | 25.3 | 25.3 |
| Annual rainfall (mm) | 757.9 | 733 | 4440 | 3842 | 661.4 | 727.8 | 812.6 |
| Dry period (days) | 144 | 161 | 112 | 168 | 168 | 175 | 178 |
| Relative humidity (%) | 67 | 76.6 | 83.3 | 84 | 65 | 69 | 69 |
| PET (mm) | 1482.60 | 1466.10 | 1465.80 | 1796.90 | 1527.40 | 1790.93 | 1523.26 |
| **Site characteristics** | | | | | | | |
| Elevation (m) | 830 | 762 | 151 | 23 | 733 | 801 | 850 |
| Slope (%) | 3-5 | 3-5 | 15-25 | 5-10 | 1-3 | 3-5 | 1-3 |
| Drainage | Well | well | well | well | well | Well | well |
| Depth of water table (m) | 10-25 | 10-25 | 10-25 | 10-25 | 5-10 | 10-25 | 10-25 |
| Erosion hazard | Moderate | Moderate | Moderate | Moderate | Slight | Moderate | Moderate |
| **Soil characteristics** | | | | | | | |
| Depth (cm) | 146 | 107 | 151 | 142 | 151 | 175 | 156 |
| Texture | scl | scl | scl | gscl | scl (swell-shrink) | C | scl |
| Gravel (%) | 34 | 53 | 2.47 | 61 | 0.52 | 3.2 | 13.72 |
| **Soil fertility (0-25cm)** | | | | | | | |
| pH | 7.44 | 8.34 | 5.66 | 5.37 | 8.08 | 8.03 | 8.29 |
| CEC (cmol (+) $kg^{-1}$) | 13.95 | 14.65 | 6.91 | 6.68 | 17.17 | 21.72 | 11.40 |
| Base saturation (%) | 86.4 | 92.03 | 70.1 | 81.3 | 89.39 | 90.12 | 84.09 |
| Organic carbon (%) | 0.54 | 0.47 | 1.47 | 1.21 | 0.4 | 0.65 | 0.61 |

Land suitability classification of major coconut-growing areas of southern Karnataka are mentioned in table4. Krishnarajapete and Arasikere areas had ideal conditions with respect to drainage, depth of water table, soil texture where as Krishnarajapete had relative humidity, potential evapo-transpiration, slope,soil depth, gravel, pH, base saturation and organic carbon content which are highly suitable for coconut cultivation with no or slight limitations but Arasikerehad relative humidity, potential evapo-transpiration (PET), elevation, slope,soil depth making it highly suitable for coconut cultivation with no or slight limitations. Beltangadi and Brahmavara had similar ideal conditions with respect to mean annual temperature, relative humidity, elevation, drainage, depth of water table, soil characteristics and organic carbon content where as Beltangadi had dry period, PET, pH and base saturation which are highly suited for coconut cultivation and Brahmavara had PET, slope, texture and base saturation which are highly suitable for coconut cultivation with no or slight limitation. Hosadurga had ideal to highly suitable conditions for coconut cultivation with respect to mean annual temperature, relative humidity, PET, elevation, slope, drainage, depth of water table, erosion, soil depth, gravel, CEC and base saturation. Turuvekere and Gubbi had ideal to highly suitable climatic requirements like mean annual temperature,

relative humidity, PET and site characteristics like slope, drainage and depth of water table. All the soil characteristics are found to be ideal for coconut cultivation in Gubbi and Turuvekere (except texture). CEC and organic carbon in Turuvekere whereas organic carbon and base saturation in Gubbi were found to be highly suitable for coconut cultivation.

**Moderately suitable lands**

**With three moderate limitations**

Krishnarajapete (Mean annual temperature 24.7 ºC, 757.9 mm rainfall and 144 days dry period, 830 m above MSL elevation, moderate erosion and 13.95 cmol (p+) $kg^{-1}$cation exchange capacity) had 3 moderate limitations.

**With four moderate limitations**

Arasikere **(** 23.6 ºC mean annual temperature, 733 mm rainfall and 161 days dry period, moderate erosion, 53 per cent gravel and 8.34 pH, 14.65 cmol (p+) $kg^{-1}$, 92.03 per cent base saturation and 0.54 per cent organic carbon) had four moderate limitations.

**Marginally suitable lands**

**With single severe limitation**

Turuvekere (175 days dry period) and Gubbi (178 days dry period) exhibited single severe limitation for coconut cultivation.

**With two severe limitations**

Hosadurga (661.4 mm mean annual rainfall, 168 days dry period and swell-shrink type of clays) and Beltangadi (15-25 % slope and 6.91 cmol (p+) $kg^{-1}$cation exchange capacity) had two severe limitations.

**With three severe limitations**

Brahmavara(168 days dry period, 61% gravel and 6.68 cmol (p+) $kg^{-1}$ cation exchange capacity ) had three severe limitations for coconut cultivation.

**Table 3: Climatic and soil-site suitability of major coconut growing areas of southern Karnataka.**

| | Krishnarajapete | Arasikere | Beltangadi | Brahmavara | Hosadurga | Turuvekere | Gubbi |
|---|---|---|---|---|---|---|---|
| **Climatic requirements (c)** | | | | | | | |
| Mean annual temperature (°C) | S2 | S2 | S0 | S0 | S1 | S1 | S1 |
| Annual rainfall (mm) | S2 | S2 | S2 | S2 | S3 | S2 | S2 |
| Dry period (<50 mm) | S2 | S2 | S1 | S3 | S3 | S3 | S3 |
| Relative humidity (%) | S1 | S1 | S0 | S0 | S1 | S1 | S1 |
| PET (mm) | S1 | S1 | S1 | S1 | S0 | S1 | S0 |
| **Site characteristics (t)** | | | | | | | |
| Elevation (m) | S2 | S1 | S0 | S0 | S1 | S2 | S2 |
| Slope (%) | S1 | S1 | S3 | S1 | S0 | S1 | S0 |
| Drainage | S0 | S0 | S0 | S0 | S0 | S0 | S0 |
| Depth of water table (m) | S0 | S0 | S0 | S0 | S1 | S0 | S0 |
| Erosion hazard | S2 | S2 | S2 | S2 | S1 | S2 | S2 |
| **Soil characteristics (s)** | | | | | | | |
| Depth (cm) | S1 | S1 | S0 | S0 | S0 | S0 | S0 |
| Texture | S0 | S0 | S0 | S1 | S3 | S2 | S0 |
| Gravel (%) in control section | S1 | S2 | S0 | S3 | S0 | S0 | S0 |
| **Soil fertility (0-25cm) (f)** | | | | | | | |
| pH | S1 | S2 | S1 | S2 | S2 | S2 | S2 |
| CEC (cmol (+) $kg^{-1}$) | S2 | S2 | S3 | S3 | S1 | S1 | S2 |
| Base saturation (%) | S1 | S2 | S1 | S1 | S1 | S2 | S1 |
| Organic carbon (%) | S1 | S2 | S0 | S0 | S2 | S1 | S1 |
| | S2 c,t,f | S2 c,t,s,f | S3 t,f | S3 c,s,f | S3 c,s | S3 c | S3 c |

S0 – Ideal
S1- Highly suitable
S2-Moderately suitable
S3-Marginally suitable
S4-Not suitable

**Table 4: Land suitability classification for major coconut growing areas of southern Karnataka**

| Land suitability unit | Interpretation | Pedon |
|---|---|---|
| S2 c, t, f | Moderately suitable land with moderate limitation of climate (mean annual temperature, rainfall and dry period), site ( elevation and erosion) and fertility (cation exchange capacity). | Krishnarajapete |
| S2 c, t, s, f | Moderately suitable land with moderate limitation of climate (mean annual temperature, rainfall and dry period), site(erosion), soil characteristics (gravel) and fertility (pH, CEC, Base saturation and Organic carbon). | Arasikere |
| S3 t, f | Marginally suitable land with severe limitation of site (slope) and fertility (CEC). | Beltangadi |
| S3 c, s, f | Marginally suitable land with severe limitation of climate (dry period), soil characteristics (gravel) and fertility (CEC). | Brahmavara |
| S3 c,s | Marginally suitable land with severe limitation of climate (rain fall,dry period) and soil texture. | Hosadurga |
| S3 c | Marginally suitable land with severe limitation of climate (dry period). | Turuvekere |
| S3 c | Marginally suitable land with severe limitation of climate (dry period). | Gubbi |

Climatic requirements (c)

Site characteristics (t)

Soil characteristics (s)

Soil fertility (f)

**Conclusion:**

Annual rainfall was moderately to marginally suitable for coconut cultivation at different study areas. Soils of Beltangadi and Brahmavara in general are acidic where as other locations had near neutral to mildly or moderately alkaline soils and electrical conductivity was low in all locations.Among the soil characteristics, depth,texture and coarse fragments are critical for coconut cultivation. Among the soil chemical factors pH, organic carbon and base saturation decide suitability of soils for coconut cultivation.Soil moisture is found to be a very critical input for coconut cultivation. As most of the areas have prolonged dry spell, providing life saving irrigation plays a very important role in maintaining the palms under healthy conditions and in situ conservation of soil moisture also plays an important role.Liming has to be done in coconut gardens of coastal areaslike Brahmavara and Beltangadi to correct soil acidity and to ensure adequate supply of calcium and magnesium. Increasing productivity of coconut has to be done by way of promoting coconut cultivation in areas which show high and moderate suitability and restricting at marginally suitable locations.



**References:**

All India final estimates of area and production of coconut (2017) Coconut development board (CDB), Dept. of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Government of India.

Begon, J. C., Hardy, R. and Mori, A. (1978) Un systeme de cfassement des terressuivant Ieuraptitude d la production agricole. Academic d'Agriculture de France. Extrait du procesverbalde la seance du 22 Nov. 1978, pp. 1274-1285.

Bibby, J. S. and Mackney, D. (1969) Land use capability classification. Harpenden: Soil Survey of England and Wales, Technical Monograph No. 1.

Chambers, R. and Carruthers, I. (1981) Rapid rural appraisal for rural development. Agricultural Administration **8** (6), 407-422.

FAO (1976) Framework for Land Evaluation, Soils Bulletin No. 32 (Food and Agriculture Organization: Rome).

Jackson, M.L. (1973)*Soil Chemical Analysis.* Prentice Hall of India (pvt) Ltd., NewDelhi.

James Ngowi and Michael Stocking,1989, Assessing land suitability and yield potential for coconuts in Tanzania,*Applied Geography*, **9**, 21-33.

Klingbiel, A. A. and Montgomery, P. H. (1961) Land capability classification. Washington,D.C.: US Department of Agriculture, Agriculture Handbook 210.

McCormack, D. E. and Stocking, M. A. (1986) Soil potential ratings. I. An alternative form of land evaluation. Soil Survey and Land Evaluation, **6** (2), 37-41.

Naidu, L.G.K., Murthy, R.V., Hegde, R., Challa, O., Krishnan, P. and Gajbhiye, K.S. (2006) Soil-Site Suitability Criteria for Major Crops, Technical Bulletin no. 129, National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur.

Sarma, V.A.K., Krishnan, P. and Budihal, S. L. (1987) Laboratory methods NBSS-Publ. 14, Technical Bulletin, National Bureau of Soil Survey and land use planning,Nagpur pp. 76-97.

Sehgal, J. L. (1996)*Pedology – Concepts and Application*, Kalyani Publishers, New Delhi (India) pp.126-142.

Soil Survey Staff (2014)*Soil Taxonomy – Keys to Soil Taxonomy (Twelth edition).*United States, Department of Agriculture, Washington DC, USA. P.362.

Sys, IR., C., Van Ranst, E., Debaveya, IR. J. AND Beernaert, F. (1993) Land evaluation part-3. *Crop Requirements Agri. Publ*., **7** :122-136.

Walkley, A. and Black, I.A. (1934) An examination of the Degtjareff method for determining soil organic carbon, and proposed modification of the chromic acid titration method. *Soil Science*,**63**, 29-38.

World area, production and productivity of coconut growing countries (2015) Asian and Pacific Coconut Community (APCC) Statistical Year Book.