AGRO – CLIMATE AND ITS IMPACT ON COFFEE CULTIVATION IN SANA'A GOVERNORATE "YEMEN"

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Abstract

Yemen has been a center of the commercial coffee cultivation and trading since the 16th century and local production is said to date back to the 5th centaury. Export of coffee is mostly done through the port of Mocha. The Republic of Yemen (ROY) is located in the southwestern part of the Arabian Peninsula, an area that is categorized, as one of the arid regions of the world, with a land area is 527,890 square kilometers excluding the many islands in Red See and Arabian Sea. It was called Yemen Felix (Al-Yaman Assa'eed) or Arabia Felix. Yemen has a unique multi-climatic zones and year-round-cropping due to its physiographic and location. It was known as the food basket of Arabia, because of its fertile land and active population as well as the intensive effort applied in farmland.

Coffee crop is considered as a cash crop, increasing the national income, and foreign currency. In the recent years there is a sharp decrease in the production of coffee, because the presence of other competitive crop especially Qat. At present the land under coffee cultivation is 9115 hectares and Qat cultivation is 41,173 hectares in Sana'a governorate. Coffee cultivation needs favorable climatic conditions with temperature between 10-30 °C and rainfall 800mm well distributed through out the growing period. It needs fertile land and good draining soil with a minimum depth of 2 m and PH 5.2 to 7.The productivity of coffee varies every year in the area under coffee cultivation recorded in 1990 was 7205 hectares and production is 1,771 ton, but in 2002cultivated area is 9165.21 hectares and number of coffee trees is 10219844. Coffee Arabica is the best quality and it is an indigenous variety. It is essential to study the cause for the declining productivity of coffee and find solution to the problem.

Introduction:

Since the last two decades a noticeable shift towards climatic studies has been noticed. Farmer was cultivate in randomly way with unaware the climatic conditions and weather changes, but Geographers realized that climatic conditions effects on all human activities, especially agriculture, which bad weather damages cultivation crops and effects on quantity of production.

In Sana'a governorate coffee cultivation is prominently consist of here 23.37 % from the total production in Yemen, which consider first governorate for coffee production in Yemen.

Objectives:

- To define the relationship between climatic elements and productivity of coffee plant.
- To know exactly which area cultivatable regions for coffee plant.
- To know the effect of climatic elements on cultivation of coffee plant in Sana'a governorate.
- To classify the ideal regions for coffee cultivation and production.

Methodology:

- Multiple correlations were done for the climatic elements and productivity in Sana'a governorate.
- Data sources

  1. Yemen meteorology service in Sana'a governorate.
  2. The agriculture statistical obtained from ministry of agriculture in Yemen during the year 1990-2001.

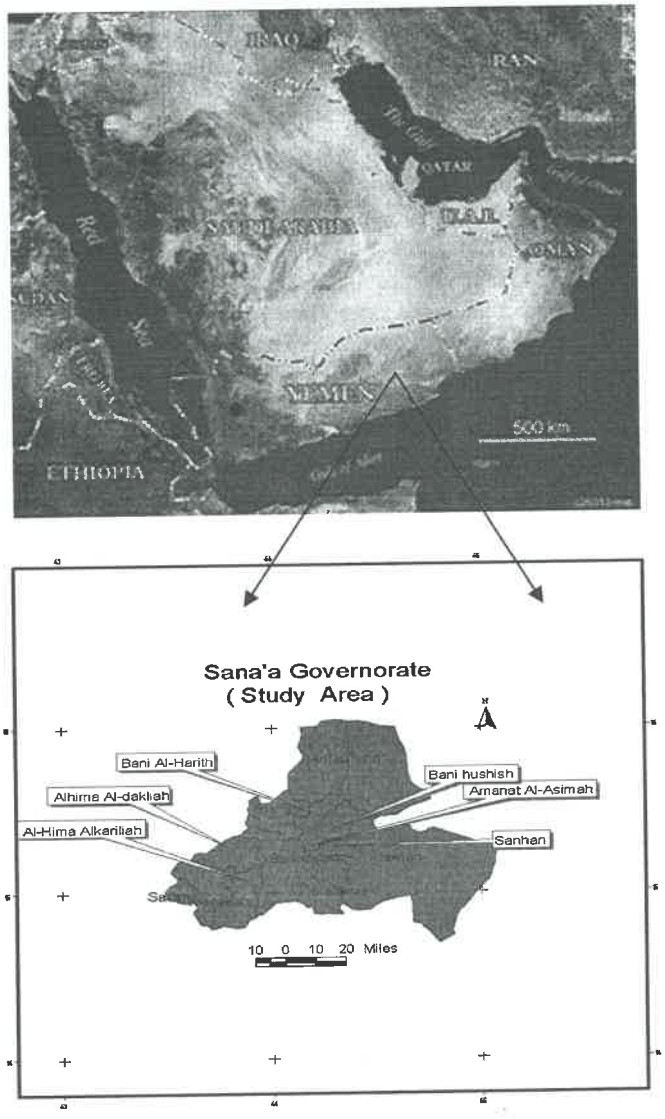
  - Analysis through MapInfo Professional and Arc View software.

Study area:

The Republic of Yemen is located in south of Arabian Peninsula, between latitudes 12°-19 north of equator and 41°-54° east of Greenwich. The country is bordered by Saudi Arabia in the north, Oman in the east, the Arabian Sea and the Gulf of Aden in the south and Red Sea in the west. The total area of Yemen is approximately 5, 27,970 square kms. The study area includes Sana'a governorate, which consist of 14 districts.

Sana'a governorate is located between latitudes 14°.40 - 16°.20 north of equator, and 43°.30-45°.5 east of Greenwich. Sana'a lies mid of the western mountainous chain; it is surrounded by a number of Governorates: Amran to the north, Dhamar to the south, Al Jawf and Mareb to the east, Hodiedah to the west and on the northwestern direction are the two Governorates of Hajjah and Al Mahwit. The total area of Sana'a governorate is about 11,962.4 square kms. Most of this area is used for agriculture which might grow different kinds of agricultural crops Fig 1.

Figure (1) location map of Yemen



Physical features:

Sana'a governorate physically consists of two kinds of geographical zones:

- Western mountains
- Eastern Mountains
- Valleys

Western mountains: This kinds of mountains located in western districts and western north starting from Bani Matar, Al-Haima, Al-Dakhliah, Al-Hima-Al-Kharigiah, Haraz. This part characteristic with heavy rain, as a result of its position is opposite to direction of the wind season, which the population depends on in agriculture. The topographic here is very rugged and cut by wadis, 1500-2000m deep, ravines and canyons in several places, sometimes with almost vertical walls that make them virtually inaccessible,(*Al-jibly,1993),p22.* These central highlands bounds between the foothills and highlands. It comprises the high parts of the country with elevation between 1500-3760m. These districts, which located in this part are famous of coffee cultivation, because, it's received rain more than another district in study area.

Eastern Mountains: There are many low lands spreads in steady area as Sana'a low land, which consider the important one. Also there are so many of small low lands, which spread in many district. The most of these low lands content fertile agricultural lands which depends on ground water in agriculture such as Al-Fir, Al-Salahi, Al-Mlah low lands in Bani Hoshish district, Al-Horrah low land in Hamdan district, Al-Rokia, Shaker, Sanwan in Arhab district, Habab in Sanhan district, Mazir low land in Blad Al-Rose khawlan district. These districts are arid and receive rainfall less than any districts in study area and the climate conditions not suitable for coffee cultivation.

Valleys: There are many high mountain and plateau in study area, which has many of wadies that located between the mountains. We can know the directions of there wadies depending on the mountain.

Climate of Yemen:

The topographical variation of Yemen has given a range of climatic conditions. These climatic variations here helped in the growth of a wide variety of both tropical; subtropical crops. The climatic zones are ranging from tropical in the coastal and desert zone and subtropical in the southern slops including western and eastern mountains to moderate in the highlands. The climate is generally dry and temperature rarely exceeds 32°C in summer while in winter nights the temperature sometimes falls down below zero. The rainfall in Sana'a governorate starting in April to May and discontinue June, July and again starting August till October exactly in the western area. . The summer monsoon in Yemen varies from zone to zone and region to region.

Coffee cultivation in Yemen: -

The mountains and slopes contain terraces, which are uses for agriculture. These terraces were built times of the origin settlements during in this region, photo (1), the framers build it because these terraces prevent the soil erosion by floods during the monsoonal rainfall. The traditional water harvesting –runoff irrigation scheme simply leads water from the up- slope area in controlled way to the upper terrace. From there it cascades downwards terrace-by-terrace. Only in the lower part of the valley the water concentrates in the wadi-channels. This system makes optimal use of the water supplied by the harvesting area, but it is extremely labour-intensive. The upper terraces are more or less pure sediment traps and orison protection for the lower field. The walls must be raised or the sediment removed.

This traditional system was changed in the late sixties/early seventies of the last century in several; steps, many channels were cut from the uphill run off areas through the terraces down to the wadi. The main object of the change was to reduce sedimentation in the terraced fields. The new channels eroded within the 30 years down to the base rock of slope and caused erosion and water losses on the adjacent terrace.

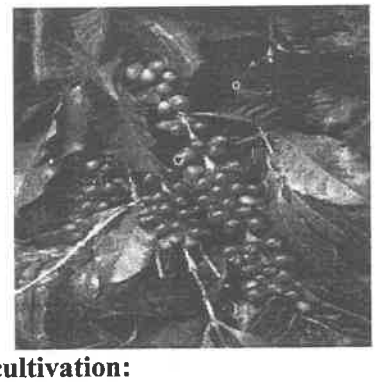
Figure (2) coffee cultivation in Yemen

Photo (1) Terraces in study area

Description of coffee plant

Mocha coffee was a dominant of international trade coffee. A coffee tree consists of three main parts; roots, green parts and fruits. The flowers blossom from the lateral branch and the main stem, but the blossom of these flowers depends on moderate temperature and rainfall in March photo (2.3) the maturity if coffee seeds needs 8-10 months but in warm areas it takes a short period.

Photo (2 & 3)



Optimum climatic conditions for coffee cultivation:

The topography and climatic conditions in study area plays role in quantity of coffee production:

Elevation: coffee plantations in Yemen are found at altitudes between 1000 m to 2000 m along the upper courses of wadis cutting out the mountainous region. But the ideal elevation for coffee cultivation is 1300-1500m above sea level.

Soil: Haarer (1950) considered good coffee soil those with a PH 6-7. Van Royen (1954) in his review that the best coffee soils are generally from forest lands that, at one time were rich in humus. In Central America El-Salvador-Guatemala, Nicaragua, Java, Uganda, Tanganyika where excellent coffee is grown in comparatively newly formed volcanic soils. On other hand Jean Nicolas (2004) the types of soil best suited for coffee are those that originate from lava / volcanic ash, basic rocks and alluvial. The soil in Sana'a valleys is chiefly accumulated by the effect of wind and water erosion nearby mountains.

Rainfall:

The ideal rainfall necessary is 800mm with good distribution of not less than 125 rainy days (commission of the European communities 1992) but (Fredrick L.1961) coffee Arabica is grown where yearly rainfall is around 1905mm. however some of the highest production of coffee in the Costa Rica comes from a region where the rainfall often reaches 2,794 mm and even more annually. And also Ranganath (1997), heavy rainfall of about 1500-2000 mm well distributed through out the years essential for the cultivation of coffee.

Temperature:

The maximum of temperature in a day should not exceed 30 °C for extended periods and should not similarly fall below 10°C for such periods. [*Commission of the European Communities, 1992, P, 9].*

Climatic conditions in study area:

Sana'a governorate has received the lowest rainfall 40mm in 1990 and the highest rainfall 302.2mm in 2001. (*Yemen meteorological service-general directorate of climate 2003*) table (1).

The maximum of temperature recorded in Sana'a governorate during Jun 32.3 °C and minimum temperature is 12.3 °C, but the temperature is decrease in the winter season exactly January is 26.6 °C and minimum -2.5 °C.

Table (1) Quantity of rainfall in study area

Station	Jan	Feb	Mar	Apr	May	Jun	JUL	Aug	Sep	Oct	Nov	Dec	Total
Sana'a city	2.5	5.9	18.7	40.6	20.2	11.5	16.6	17	1	0	0	4	138
Airport	5.9	12.5	18.7	39.6	17.8	5.7	25.4	36.9	5.3	8.5	3.5	3.3	183.1
Sana'a	2	4.1	25.4	39.8	16.3	9.2	26.8	38.4	2.7	3	1.3	2.5	171.5
Hammam Ali	0.5	25.2	36.1	71.4	54.1	3.4	37.2	84.9	15.5	4	0	5.6	337.9
Al- Kalifa	4.3	45.3	4.9	51	31.2	27.9	18.8	78.9	133	78.3	0	6.6`	473.6
Ideal	95	97	106	127	298	279	113	88	90	96	131	120	1640

Figure (3) Quantity of rainfall in study area and ideal of water used for coffee plant

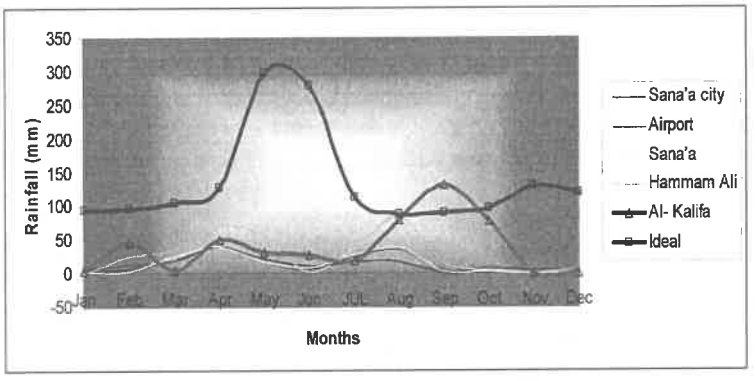


Table (1) shows the quantity of rainfall in some stations in study area or around of Sana'a governorate, where the rainfall is decline when the time coffee seeds needs water more and more moisture, in addition this area (Sana'a governorate) received solar radiation more than any place in the western slops in Yemen and most of the districts could be located in the rain shadow. How ever the efficiency of rainfall is substituted by irrigation. Also table (1) shows the western districts as Manakah, Al-Haimah Al- Dakliah, Al- Haimah Al- Karijiah, and Bani Matar districts receive rainfall more than eastern districts between 300-500 mm, so we find coffee cultivation spreads in western districts only. There are small dams made to collect rainwater by every farmer in the farm and the irrigation by artesian wells in the valleys. This water is just sufficient to supply the seeds and crops during the dry period.

Temperature for coffee plant: Yemen is considered as hot regions, where the sun vertical twice during May and July per year. Study area is exposure to maximum quantity of solar radiation (around 15.4 Mj/m²/day during December and 19 Mj/m²/day during Jun, FAO, 1997 Annex 1.24. This is reflected on increasing of temperature that means there is correlation between solar radiation and temperature increasing and this will affect on cultivation and production of coffee plant in study area. The observed data of meteorology and agricultural statistics the suitable area, which have suitable climate for cultivation generally, and especially for coffee plant in western slops of Sana'a governorate, where the population density increases in these districts. Coffee plant "Arabica" indeed cannot resist freezing when temperature decreases that plant stops growing and loses it is leaves, which means negatively affect. Whereas the high temperature above 35 °C during the growth causes falling burgeons and blossoms of the plant so that the production reduces.

The optimum temperature for coffee cultivation between 17-22 °C during night and daylight respectively, table (2).

Table (2) boundary of temperature (maximum, minimum & optimum) for coffee cultivation and good production

Temperature / Plant	Minimum temperature (°C)	Maximum temperature (°C)	Optimum temperature (°C)
Coffee plant	10	30	17-22

Source/ Jean Niclas Wintgens, 2004, "Coffee: Growing, Processing, Sustainable, Production, Published by Die Deutsche bibliothek, printed in the Federal Republic of Germany, p, 164.
Coffee trees needs supplementary of irrigation during the flowering period, which starts at the beginning of spring season where rainfall and natural temperature are available; in case there is no rainfall during spring season, farmer has to irrigate the coffee plant to continue flowering period.

Relative humidity for coffee plant:
The air humidity play an important role in cultural life specially in the highlands of Yemen, this humidity cause the decrease of temperature and leads to formation of dew, which is considered a complementary source of rains, the crops can benefit from humidity especially before sun rise.
The formation of fog in the wet highlands of study area is helped in increasing of soil humidity and gives coffee trees suitable humidity, in addition to the other methods like shading and relative humidity is increasing in study area during rainfall season.

Risk of winds on coffee plant:
The influence of wind is depend on the kind strong winds, nature, velocity, time, and cause increasing of evaporation rate these leads to loss a long quality of water from the plant, and decreases the soil humidity. These effect become more strong if the winds are hot and dry because it will increase the air evaporate them the coffee tree can not able to reserve the water equilibrium inside the tissue and give rise dry of leaves. So the build of artifice windbreaks is necessary to protect coffee plant from strong winds during the period of growing the crops.

Shade for protection of coffee plant: -
The growth of coffee under shade for protection has advantages under certain conditions. In certain of study area there is shading such as Bani Mater district especially door valley which cultivation high trees like (Tanep) cordial Africana lam, (Ttawlak) ficus vista and some fruit trees like bananas, mango, and figs. Shade is using a giants the evil effects of strong winds which broken of coffee branch. The shade is very important to protect coffee plant from weather changes especially sudden decline of temperature and we know the coffee plant can't bear of freezes. Should be select especial kinds of high tree which using shade doesn't more stuck up the soil moister and doesn't bring some diseases and pest, *Frederick L. Welman, (1961), P, 152.*

This method aims to explain the relationship between the climatic elements and production of coffee in study area. The correlation models will be used to the present study area.
The elements of climate are included temperature, relative humidity, wind speed and rainfall) will be considered as independent variable, while the production of coffee called dependent variable will be production of coffee through 1990 – 2001 table(2,3).

Table (2) Average of climatic Elements in Sana'a governorate during the year 1990-2001

Years / Elements	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Mean temperature °C	19	19.2	18.9	18	18.4	18	18.3	19.2	18.9	18.6	19.2	18.7
Relative humidity %	44	43.8	48	44	41.5	42	45	45	43.2	38.2	38	43.5
Wind speed (m/s)	2.1	2.3	2.3	2.2	2.3	1.9	1.8	1.9	2.0	2.3	2.0	1.7
Rainfall mm	150	72.4	200	203	158.2	197.9	277.3	134	227.4	91.9	63.9	302.2

Table (3) Coffee cultivated area (ha) and production (ton) in study area during 1990-2002

Years		1990	91	92	93	94	95	96	97	98	99	2000	2001
Sana`a	Area	7205	7205	7205	7565	7792	8183	8347	8390	8810	8810	9074	7205
	%	29	31.3	30.4	30.8	30.95	29.9	28.6	26.5	27.5	26.8	27.1	27
	Production	1771	886	2658	2836	2609	2740	2794	2375	2613	2639	2692	2783
	%	32.9	16.3	32.3	32.5	30.8	30.5	26.35	30	23.1	23.6	23.7	23
	Productivity	0.24	0.12	0.36	0.37	0.33	0.33	0.33	0.28	0.29	0.30	0.30	0.30
Yemen	Area	44804	23004	23665	24569	25174	27347	29220	31618	32032	32837	33443	33641
	Production	7411	5430	8218	8727	8480	8993	10600	10320	11283	11182	11363	11906

Source: -Republic of Yemen, *Ministry of agriculture, statistical yearbooks, 1990, 1995, 1999, 2000..*

Figure 4: No. Of coffee trees in Sana'a governorate

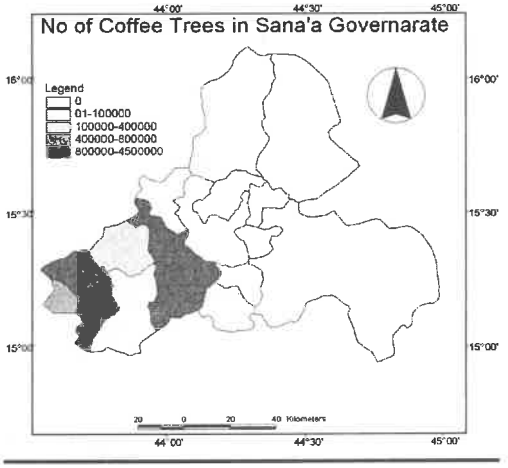


Figure 4 shows the coffee cultivation is spreads in western districts like Bani Matar first district in study area and second one Manakah district, because these districts receive rain water more than any other district in study area and the farmers used watershed and irrigation during the cultivation period. The eastern districts not suitable for coffee cultivation, because these districts located in rain shadow.

Table (4) correlation between Climate conditions and productivity of coffee in study area during year 1991

	Productivity (ton)	Rainfall (mm)	Relative humidity %	Temperature (C°)	Wind speed m/s
Productivity	1000	.180	-.142	.338	.388
Rainfall		1000	.641	.152	-.036
Rel. humidity			1000	-.294	.891
Temperature				1000	.221
Wind speed					1000

Table (5) correlation between Climate conditions and productivity of coffee in study area during the year

	Productivity (ton)	Rainfall (mm)	Relative humidity %	Temperature (C°)	Wind speed m/s
Productivity	1000	.201	.476	.070	.243
Rainfall		1000	.299	.826	.207
Rel. humidity			1000	-.046	.791
Temperature				1000	-.21
Wind speed					1000

Conclusion and Recommendations:

The main of this study is to regionalize the climate in Sana'a governorate and also describe the climatic effects on coffee production. The correlation between rainfall, relative humidity and productivity of coffee in Sana'a, governorate is positive, that means when the rainfall and relative humidity are increasing the productivity of coffee is increasing table (4&5), but when the rainfall and humidity decreases during the blossom the flowers effects on the productivity is negative. The correlation between wind speed and productivity shows the wind speed in study area is strong negative, which effect on the cultivation and productivity of coffee plant.

1- Awareness programs should be organized about the advantage of Coffee, food crops and should be organized about disadvantage of Qat cultivation; it is harmful effects on the economy, on society, health and the water resources.
2- Constructing dams and water barriers to save water got from summer rains for utilization during dry season and encourage modern technological irrigation methods.
3- Reduction in attention to coffee cultivation due to surge in Qat production and absence of a true agricultural policy to put an end to some crops like Qat cultivation, which spreads in most of area and predominant on most fertile.

Reference:

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