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Computer Aided Drip Irrigation Design for Nigerian Agricultural Environment

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Abstract

This paper reports the software development exercise for drip irrigation design targeted at features that define Nigerian agricultural environment. The package considered four agricultural zones in the country on the basis of climatic condition; i.e. South, Lower Middle belt, Upper Middle Belt, and North. The crops covered in the work were arable and perennial commercial crops popularly grown in the country. The design models that formed the background of the algorithm of the software were Crop Water Requirement Model, Hydrologic Design Model, Hydrologic Design Model and Irrigation Water Requirement Model. The finished package had 4 user's interfaces for the design environment and 1 for the output that is equipped with auto save and retrieval code, and the print option. The output of the package did not depart from the manual computation of the same design.

Keywords: Drip irrigation; Evapotranspiration model; Climate change adaptation; ClimWAT

Introduction

Nigerian economy was mostly agrarian before the attainment of political independence in 1960 [1-3]. The humid wet region in the southern part of the country was known for tree cash crop such as cocoa, coffee, oil palm, rubber, cola and timber. While cereals and grain crops were common in the northern part towards the Sahara desert. In the 50s and 70s Nigeria was ranked 2nd largest world producer of cocoa, second largest producer of cotton in Africa, and massive production and exportation of groundnut [4-9]. Over 75 percent of the entire population of the country was engaged in agriculture. Malaysia came to Nigeria to borrow leave on oil palm production only to overtake Nigeria and even become the world's largest producer of palm produce later [10-12].

The agriculture sector of Nigerian economy was reduced almost to comatose owning to the neglect it suffered at the wake of oil discovery in the 70s [12]. The oil boom was so assuring to Nigeria political leaders to the extent that many unnecessary investments in 'white elephant' projects became rampant. Rather than investing in infrastructure and manufacturing industry to complement oil, the government concentrated on bloating up political expenses and budgets continue to grow on annual basis and ostentation consumption and exotic product became the order of the day. Those farmers still hanging on to the farms were almost forgotten. Since they get no incentive, they drastically reduced their holding to the size that could sustain their family. Food supply to the urban centres dropped and the only way to ensure adequate food supply was to result to food importation to augment local supply, a practice that undermined the already weak foreign reserve [13-16]. As more of the farming families continued to drift en-mass to the urban centres in anticipation of high life, the inadequate infrastructure quickly became over-stressed. Further influx hence led to unemployment which made destitution, prostitution, crime wave and other anti-social vices to grow rapidly [17,18]. Many schools of thought suggest that the country should return to the land and give priority to agriculture that has the capacity to engage quite a number of the idle hands. The Military regime under of 1976-78 came up with Operation Feed the Nation, and the government of the second republic also paraded the Green Revolution programme. None of these programmes changes the business as usual scenario and all the resources invested on them went down the drain.

Back to the farm, much of the land was abandoned and the plantations were overgrown by need. In some areas, the plantation had reverted to derived forest. The state of the farms today is such that the farming population is weak, sick and poor and in desperate conditions. The demographic distribution skewed to the old because the farmers do not wish their children to live the way their parents did, hence send the young ones to live with relations in the cities. Those who are successful in the cities are relocating their aged parent from the bush. The farm is under continual dwindling population [18].

Many faces of Climate Change were seen in the recent time in Nigeria. Rainfalls is becoming unpredictable and is more intense whenever it comes, flooding is becoming rampant causing damage to lives an properties including farmland in line with the predictions of [19-21]. Much of the Northern region of the country is falling under desert climate. Perennial bush fire is threatening the quality of the field, forest and vegetation cover of the country. The dry spell in the dry season is becoming dryer as the dry season grows longer and extending deep into the rainy seasons. The country is still to put in place a stable structure that could withstand the wave of emergency that Climate Change effects could bring. This is evident in the recent flooding that swept through North Eastern and Eastern region of the country recently when River Benue over-flew its bound and made casualty of many families, destroy many homes and swept away several hectares of farmlands and the cultivated crops [22].

A renewed calls for the need for Nigeria to diversity its economic base, also emphasised on rejuvenation of the agricultural sector of the economy. This again led to the recent launching of yet another

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intervention agriculture programme [23,24]. This programme focuses on agricultural mechanization as a way to jump start the gap that the neglect of the agriculture sector had left in our socio-economic life. This programme projected to bring into the country several units of tractors and farming equipment. Irrigation will be given a high priority to sustain and expand the dry season farming programme supported by UNDP [25]. This is envisaged to attract the young city dwellers to the farm.

For a more stable agricultural environment, there must be adequate infrastructure and management tools on ground that can maximise productivity from the available water resource. It should be understood that irrigation is not quite common in the Southern part of the Nigeria. Bringing this facility into the agriculture of this region will be not without some teething problems. However, for successful outcome of this renewed effort to revitalized agriculture in Nigeria irrigation is but a sin-qua-non for successful outcome. Previous studies of the soil, crops, vegetation cover and prevailing climatic and environmental condition, social and human conditions of this region revealed that drip irrigation will be the most suitable for a successful practice. The spatial, institution based drip irrigation practice showed a deficiency in design. The design manual available are often location specific; requiring information on soil physical characteristics, prevailing climatic condition, crop characteristics, available and source of water and many others. This coupled with the climate change challenges, the pressure of urgency to provide food for the increasing population and the need to rescue Nigeria economy from the cliff of collapse has created a conflict of interest. One of the feasible resolutions could be found in a development of an automated tool that harmonise the scattered drip irrigation requirements, the low level of education of the farmers and the focus on optimal productivity amidst limited water resource. It should be noted that there are numerous irrigation design packages all around. Most of the off-the-shelf products do not meet the design needs of Southern Nigeria because, they were originally meant for regions other than Nigeria, and the crops for which they may be suitable are not grown in Nigeria. A trial and error with the imported system often result to ether over irrigation or under irrigation. Where over irrigation may be tolerated, it will threaten the total available water for the practice and may therefore cause a shortage at the time when the water is mostly needed. Under irrigation is not good at all. Because it will lead to reduced yield and even crop failure. Another short coming of the purchase system is that they often satisfy irrigation kits that are not readily available in Nigeria local market. Where and when they are available the price may be too high for the farmers to afford. Hence, there is a need for the development of a computer based package that captures the requirement of the country and bridge the gap that is created by the evolving situations.

Materials and Method

The materials used in this programme include the design parameters fetched from literatures. The parameters include crop type crop factor and the agronomic information, soil information, climatic data; rainfall, temperature, humidity, evaporation data and Evapotranspiration models. Software programming language: PhP, MySQL, and Dream-weaver. ClimWAT package was also used. A Laptop computer and printer were also used.

Methodology

Algorithms were developed for each routine of the package. They include, Crop Water Requirement Algorithm represented in figure 1.

ET model selected for this work was Penman-Monteith. With crop factor this algorithm will generate Crop Water Requirement. The next algorithm shown in figure 2 is the Hydraulic/Hydrology design algorithm. The sub-routine accepts input like the water source, depth and distance between water source and the intake outline. It also requests parameters of main/lateral lines. With this, the sub routing can generate the pump capacity which in turn will generate the rate of irrigation. The package made provision for linking to ClimWAT.

Figure 3 is the algorithm of the Agronomic model used in designing the volume of irrigation water. This model comprises of the field size of the land to be irrigated which is usually dimensioned in hectare. The crop water requirement which is a derivative of the evapotranspiration (ET), the soil physical parameter as it affects infiltration rate and the time per irrigation. These parameters are needed to compute the volume of irrigation water for one crop stand which is the factor that will dictate the volume of water that the entire farmland will need provided the plant population rate is known. Losses due to friction in pipe-flow and loss of water volume and pressure at the points or failed sections should be known for accurate computation.

Figure 4 shows the hydrologic design model which describes the algorithm of the subroutine of water source-field water application balance. The subroutine defines the water source in terms of volume, recharge rate, effects of rainfall and other water demands. It also accesses the vertical depth of the surface of abstraction to the inlet of the pump and the vertical height of the storage facility from where distribution main takes off. With this information and the distance

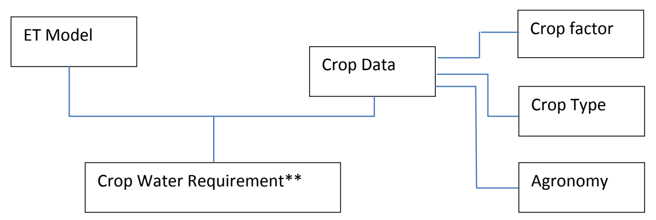

Figure 1: Crop Water Requirement Model.

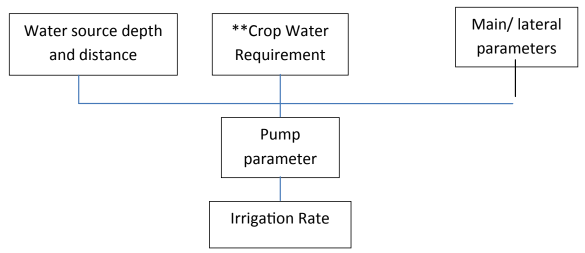

Figure 2: Hydraulic and Hydrology Design Model.

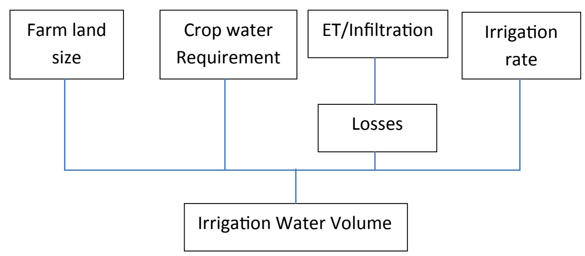

Figure 3: Irrigation Water Requirement Model.

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of the water source to the field, the subrouting then can estimate the pump lifting force required to convey the water to the field.

Results and Discussions

Among the many interfaces developed for this package is the front window interface (Figure 5) which enables users to register and declare personal information with which the computer customises the design outcome to the user. This closely followed by the output window (Figure 6) that present the result of the design according to the choice of the user. This is the template that is needed for the irrigation project implementation. All that will follow this step is the plumbing work on the field. The user may need to return to his output design at a later time. The computer automatically backs up the design and assigns it a code. The result could be printed immediately, or retrieved with the necessary indexing code. This operation is available in Retrieval Interface tagged (Figure 7).

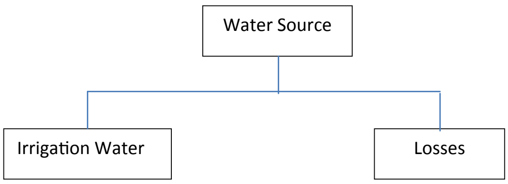
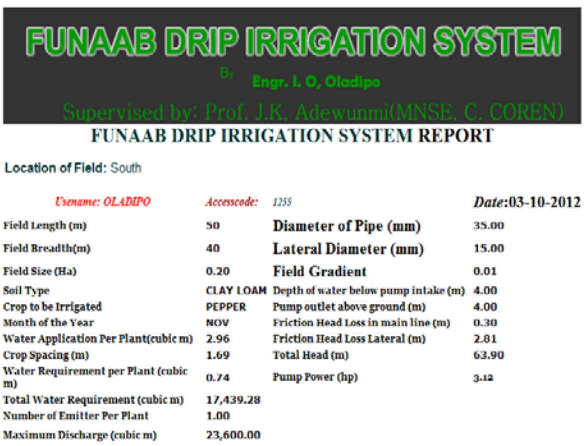


Figure 4: Hydrological Design Model.

Figure 5: Front window interface.



FUNAAB DRIP IRRIGATION SYSTEM

By Engr. I. O, Oladipo

Supervised by: Prof. J.K. Adewunmi(MNSE, C. COREN)

FUNAAB DRIP IRRIGATION SYSTEM REPORT

Location of Field: South

Usename: OLADIPO	Accesscode:	1255	Date:03-10-2012
Field Length (m)	50	Diameter of Pipe (mm)	35.00
Field Breadth(m)	40	Lateral Diameter (mm)	15.00
Field Size (Ha)	0.20	Field Gradient	0.01
Soil Type	CLAY LOAM	Depth of water below pump intake (m)	4.00
Crop to be Irrigated	PEPPER	Pump outlet above ground (m)	4.00
Month of the Year	NOV	Friction Head Loss in main line (m)	0.30
Water Application Per Plant(cubic m)	2.96	Friction Head Loss Lateral (m)	2.81
Crop Spacing (m)	1.69	Total Head (m)	63.90
Water Requirement per Plant (cubic m)	0.74	Pump Power (hp)	3.12
Total Water Requirement (cubic m)	17,439.28		
Number of Emitter Per Plant	1.00		
Maximum Discharge (cubic m)	23,600.00		

Figure 6: Design Output Interface.

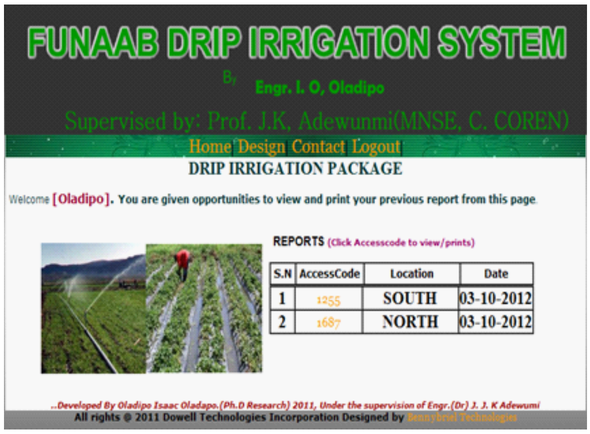


Figure 7: Retrieval Code Interface.

The high point of the interface in general is that they enable the user to select from a draw down list rather than leaving him to a wide ocean of options. This guided choice is needed to minimise errors and abuse thereby making the design output to be more reliable. The computer interaction time is reduced drastically. The programming environment enable for both conscious saving of the created file or a sub conscious backup through the automatic saving prompt. The PHP environment is capable of working in almost all popular operating system platforms apart from Microsoft. This is a boost to the coverage of the package. This provision makes online help access for users and create a network of users and administrators to collaborate and therefore share knowledge, challenges and experiences on the usage of this package which at the end promote further development of the package and the quality of service which farmers and any other users will enjoy in future. As earlier mentioned, the package made provision for linking to ClimWAT. The advantage of this linkage is for updating of climatic factor. So long as ClimWAT is updated by the developer, the users of the package will be having access to updated climatic data. This is what makes the system to play along with Climate Change and will be relevant a tool for Climate Change Adaptation.

The result of the computer based design and that computed manually is shown in table 1. Most of the design parameters were very close and therefore confirms the reliability of the system. The output sheet provided an identity for each design; having such labels as Client (user's) name, Date of design location of the field, and online result location retrieval code. These may easily be forgotten when computing manually and may render the result useless if the implementation is deferred to alter date and transferred to another project supervisor.

Conclusion

The shift towards advanced technology in Nigerian agriculture is long overdue. Nigeria cannot continue to depend on food importation to support the ever growing population at the expense of domestic agricultural development and job creation opportunities. The youths that are idle today need to be adequately motivated with incentives that will draw their attention to the land. Already most of their daily lives are enshroud in digital based technologies like the mobile phones, DVD, Wi-Fi Internet and computer embedded systems. Any activity that will successfully shift these youths away from the city life must not be too far from the conveniences of the city. This package is one of the ways to address that issue. The package is out to provide the missing link which the old scenario could not solve. The meeting of the farmers and the professionals to translation of the engineering design

Irrigation parameter	Computer Base	Manual method	Comment
Location of Field:	South	South	
User name:	OLADIPO	-	Auto
Access code:	1491	-	Auto
Date:	29-09-2012	-	Auto
Field Length (m)	50	50	No difference
Diameter of Pipe (mm)	35	35	No difference
Field Breadth(m)	40	40	No difference
Lateral Diameter (mm)	15	15	No difference
Field Size (Ha)	0.2	0.2	No difference
Field Gradient	0.005	0.005	No difference
Soil Type	Clay Loam	Clay loam	No difference
Depth below pump intake (m)	4	4	No difference
Crop to be Irrigated	Okra	Okra	No difference
Pump outlet above ground (m)	4	4	No difference
Month of the Year	Nov	Nov	No difference
Friction Head Loss in main line (m)	0.295	0.36	0.065
Water Application Per Plant (mm)	2.66	2.5	0.16
Friction Head Loss Lateral (m)	2.815	2.79	0.025
Crop Spacing (m)	1.69	1.69	No difference
Total Head (m)	63.9	27	36.9
Water Requirement per Plant (mm)	0.665	0.1	0.565
Pump Power (hp)	3.1	1.0	2.1
Total Water Requirement	53204.58 m3	40 litre/day	13.2
Number of Emitter Per Plant	1	1	No difference
Maximum Discharge (cubic mm)	800	1000	200
Total Number of PVC Pipe	13.51	13.5	0.01
Total Length to be Design (m)	51.01	60	-8.09

Table 1: Comparison between the reports of the computer based design and manual design.

to practical reality which often could not be convened is now fizzling out. The users of this package may not need any expert to be able to determine a few things to do to successfully practice drip irrigation. With just a little familiarity with the computer keyboard, and just about 8 clicks to strike, the out paper is out. All what is left will be plumbing work. This should be a good start for computer oriented production in Nigeria.

Recommendation

One major hindrance confronting introduction of technological innovations to the farmers and the rural people is the conservative attitude of the people in Nigeria. It is a surprise thing to know that the people still stick to the traditional methods when more convenient, more productive and less arduous methods abound all around us. So the people need to be reoriented to be more receptive to innovations. Without this, it may be difficult to access the performance of this package and identify areas of improvement.

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