International Journal of Environmental Impacts
Vol. 8, No. 2, April, 2025, pp. 371-380
Journal homepage: http://iieta.org/journals/ijei

Espousing Environmental Pollution Management and Control by Exploring the Bioenergy Properties of Coconut Shell Nanoparticles

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https://doi.org/10.18280/ijei.080216

Received: 7 February 2025
Revised: 4 March 2025
Accepted: 26 March 2025
Available online: 30 April 2025

Keywords:
bioenergy, biomass, environmentalism, greening, pollution, pyrolysis, renewable energy, waste management

ABSTRACT

Energy in all forms is a key requirement for human livelihood and for socio-economic development. However, overreliance on a single source of energy can cause energy management issues because of the occurrence of system over-burdening. Thus, the utilization of other forms of energy is highly promoted worldwide, with a clear emphasis on enhancing environmentalism and reducing pollution through waste management and control. This paper considers the use of digital image processing in the form of pattern recognition to extract the pattern of a coconut shell and charcoal wood to show the correlation between their patterns. Thus, deducing the energy properties of the coconut shell. A 3D camera is used to capture the digital image of the preprocessed coconut shell. The appropriate algorithm is then written on the MATLAB software toolbox to manipulate and translate the digital images, hence revealing its hidden nature. The technical process of scrutinizing the hidden properties involves the changes of pixels of the images, enhancement and thresholding; which is the pattern revealing step. Finally, the automatic pattern recognition toolbox acts to recognize the resemblance of the pattern of the coconut shells to the wood charcoal in order to analyze the pattern directly and determine the energy property percentage indices of the agent under test. The results indicate that out of a total of 180 samples of dataset for coconut wood and 178 samples of dataset for charcoal wood, 179 and 177 samples were correctly predicted for coconut shell and charcoal wood, respectively. Thus, the overall accuracy is 99.4% which indicate that coconut shells is carbon based, first- generation bioenergy crop and has high bioenergy properties and again a lower ignition property compared to charcoal wood.

1. INTRODUCTION

Modern technological advancements and their associated benefits make it possible for most branches of research and technology to be conducted using image processing methods. This is because, the later has a wide range of applications such as biomass analysis, medicine (X-rays, Magnetic Resonance Imaging (MRI), analysis of cell images), agriculture application via aerial views, inspection of fruits and vegetables, industry applications by automatic inspection of items, law enforcement via the usage of fingerprint analysis and many more. All these applications show that image processing and analysis today provide a solid tool to solve many real-life problems. In the security field, digital image processing is used to analyze Closed-Circuit Television (CCTV) surveillance systems by using various techniques [1] to assure security, monitor road traffic and even track fraudsters and law enforcers. Similarly, the medical fields have also been affected by the use of digital image processing to reveal unseen diseases following pregnancy [2] and many more applications.

Agriculture, especially, is one of the biggest sectors producing a massive amount of waste every year [3] which affects the environment. But this amount of biodegradable waste generated can be converted to a tremendous amount of energy. Perceived as the future of renewable energy sources, biomass is promising since the composition of its structure plays an important role in the emission of heat for the transformation of biofuels [4].

Therefore, considering the numerous advantages of proper waste management, such as limitation of greenhouse emissions, reduction of pollution, provision of bioenergy such as heat, electricity, etc. Ultimately, proper biomass management must be conducted in such a way that it profits humanity and nature [4].

This project will have a great environmental and also economic impact because energy production, such as heat, is mostly done by burning woodfire, which causes deforestation.

Whereas coconut shells; which is mostly considered waste, and also possesses some energy properties, which is comparatively more profitable and so the need for research to prove of its composition of a good source of bioenergy.

Digital image processing and analysis have been undergoing a vigorous growth as a subject of interdisciplinary study and has been applied for research in several fields for pattern recognition. Pattern recognition and image processing have similarities, the process of processing details of an image by improving its appearance and ensuring that it is properly represented, it does not only involve image coding, filtering, enhancement and restoration, but also feature extraction, analysis and recognition of the image [5].

Recently, image processing has largely been utilized for quantitative analysis of biomass and other biological systems such as bacteria and yeast. Biomass could be defined as a renewable natural fabric which comes from plants and animals and can be handled to be utilized as fuel or to create power.

What is yet to be established has to do with the signal processing of coconut shell using an appropriate tool.

Digital image processing was applied to measure and quantify the biomass of an organic matter, this method is a simple and efficient way to analyze the biomass content of an element and its properties needed for many purposes [6].

This study focuses on the analysis of the energy properties of coconut shells by using a combination of digital image processing and pattern recognition. It was established that the bioenergy properties of coconut shells will ultimately combat existing issues relating to the recycling of coconut shells which includes environmental pollution. Thus, environmentalism and greening are enhanced [7].

1.1 Problem statement

Currently, the recycling of coconut shells is a major problem in Ghana, and coconut is produced on approximately 11.8 million hectares of land in 92 countries around the world. Ghana is ranked 16th in production, producing 366.183 tons of coconut [8].

Though Ghana generates tons of coconut shells annually; out of which a small percentage are burned as fuel. The remainder is normally discarded as waste. Coconut sellers dump coconut shells and shuck after close of business and this has contributed to pollution in Ghana. The environment cannot be protected if waste materials are not managed, a lot of people are not aware of the huge economic potential and uses of coconut shells. It's important to prove that, coconut shells possess remarkable properties which can be an alternative energy source due to its several characteristics. Coconut shells should not be considered as a waste that degrades the environment but rather be considered as one with high potentials in the renewable energy and recycling industry.

1.2 Research objectives

The main objective of this study is to analyze the energy properties of coconut shells by using digital image processing and pattern recognition through matrix laboratory (MATLAB) software.

1.2.1 Specific objectives

•To acquire digital images of coconut shell and identify its inherent patterns to facilitate the analysis of its energy properties;

•To compare patterns of coconut shell and other related carbon-based biomass using thresholding;

•To validate the analysis of energy properties of coconut shell.

2. REVIEW OF DIGITAL IMAGE ANALYSIS

Digital image analysis is an area meant for establishing quantitative measurement to generate the description from an image. At the most advanced level, image analysis is crucial as it might be the center of important decision making. Image analysis techniques may require the addition or extraction of some elements to aid in achieving the desired goal [9, 10]. The different techniques used are as follows:

Image classification: The identification and extraction of information classes from a multiband image with a unique gray level or color happens at this stage.

Image segmentation: A technique that enhances digital image analysis by partitioning a digital image into various subgroups of pixels to reduce the complexity of the image and make analysis simpler.

Image particle analysis: This refers to the technique applied to identify tiny particles and increase their size, and also reveal their shape for the analyst to extract the desired output.

Thresholding: Similar to image segmentation, thresholding consists of changing the pixels of an image for easy analysis. It's applied to select the areas of interest of an image while ignoring the rest of the image.

Grayscale: Mostly used in photography, grayscale analysis is a technique where the concentrations of all colors present in the picture are equally sampled to obtain a gray fading. For example, bright colors such as red, blue, and green are combined according to their pixel concentrations to form other colors. In this analysis, the pixels of these three colors are equally combined to obtain a gray fading color, making it easier to analyze the image.

2.1 Analysis of biomass (coconut shell) and its energy properties

Biomass is defined as a renewable organic material that comes either from an animal or a floral source and can be used as a source of energy (bioenergy), such as fuel or electricity. Here, a case is placed on coconut shells [11].

Biomass contains various organic molecules such as hydrogen, oxygen, alkaline and heavy metals depending on the source but remains a carbon-based element. Many processes are used to transform this material into an energy source, but the common processes are:

Photosynthesis: A process by which green plants absorb light energy and convert their organic molecule into chemical energy.

Pyrolysis: A process in which organic materials are subjected to thermal decomposition at elevated temperatures in an inert environment.

In 2018, Chung et al. [12] researched the estimation of sorghum biomass using digital image analysis with Canopeo, where digital images were applied to analyze the correlation between the state of sorghum plant growth and production of biomass. Here, the research has been conducted throughout the evolution of the sorghum plant to demonstrate the correlation between plant height and biomass generation.

Congruently, coconut shell is the hardest part inside the husk of a coconut that protects the soft part of the fruit. Coconut has two states; these the mature state, which means that it made up of an average of 15% shell or dried with an average of 23% shell [13]. Figure 1 shows the composition of a matured and dry coconut by weight.

Coconut is produced in 92 countries around the globe and occupies more than 10 million hectares [14]. Coconut shell is a great renewable biomass energy, and its presence everywhere is considered a source of energy rather than pollutant.

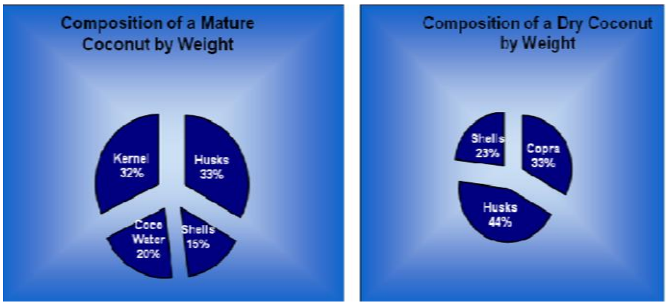

Figure 1. Compositions of mature and dry coconut by weight [13]

Coconut shells have a high calorific value of 20.8 MJ/Kg [14] and can be used to generate steam, energy-rich gases, bio-oil, biochar, electricity and heat. The transformation of biomass into energy is conducted via pyrolysis. The ignition properties of coconut shell are not yet established. Hence, conducting more research with different approaches to further exploit the energy properties of coconut shell is needed.

In 2020, Asgharnejad and Sarrafzadeh [15] explored the use of digital image processing as a new method to measure activated sludge biomass. They took photos of the sludge using a Nikon D5300 camera with a Nikon 18–140 mm f/3.5–5.6 VR lens. By using a fixed zoom setting, they were able to capture larger and clearer images.

To analyze the images, they applied RGB (Red, Green, Blue) analysis to balance the bright colors and convert them into shades of gray. This made it easier to focus on the sludge particles needed for measurement. Their study showed that digital image processing is a useful tool in accurately quantifying biomass.

Mishra et al. [16] studied the full outer layer (exocarp) of the coconut shell by first removing it to access the inner hard shell (endocarp) that surrounds the coconut. The endocarp was then washed and sterilized to prepare it for drying. After drying, it was broken into smaller pieces, ground into coarse particles, and further processed to achieve more uniform particle sizes.

The composition of coconut shell nanoparticles was determined through viability tests. Additionally, energy-dispersive X-ray spectroscopy (EDX) and X-ray analysis were used to identify the chemical composition of the coconut shell.

Thresholding techniques were applied to analyze the images of the coconut shell nanoparticles. This involved adjusting image pixels and selecting optimal edges to study the effects of processing time and digital image processing on the material's microstructure.

Despite various studies on the properties of coconut shells, limited research has been conducted in Ghana. Therefore, there is a pressing need to apply modern technologies to analyze coconut shells produced in West Africa and compare their properties with those from other tropical regions [17].

3. METHODOLOGY

3.1 Required specification

Digital image processing has proven to achieve accurate results when applied in pattern recognition and correlational purposes and assumptions. This is done through various steps, such as the following:

•Image acquisition represents the start point of work and the most important step as well. Without an image, nothing can be processed. Thus, no image processing can be conducted before obtaining an image.

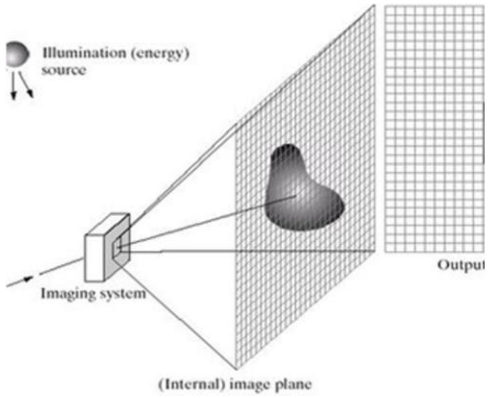

Figure 2. Example of image acquisition [17]

Here, the internal image plane is illuminated as shown in Figure 2.

Image enhancement, which consists of processing the image while using different digital image processing methods in order to remove any defect that can affect the image as shown in Figure 3.

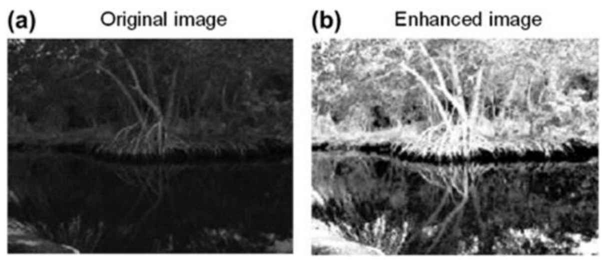

Figure 3. Example of image enhancement [18]

Image segmentation, refers to the partition of the image into different parts called segments to assist the identification of the objects in the image. Figure 4 illustrates a segmented image.

Figure 4. Example of image segmentation [19]

Thresholding is a method of converting an image to binary image as shown in Figure 5. It involves the processing of white and black images out of a grayscale image by arranging their pixels to white having a value above a given threshold.

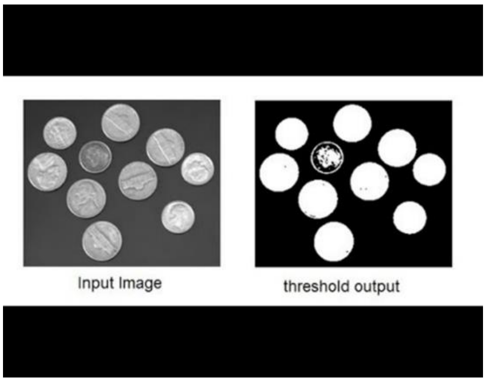

Figure 5. Example of using thresholding to convert an image [19]

3.2 Digital image processing procedure

This process involves the application of a knowledge-based algorithm to acquire, restore, enhance, segment, compress and recognize an image. Figures 6 and 7 illustrate the steps and fundamental diagram of digital image processing respectively.

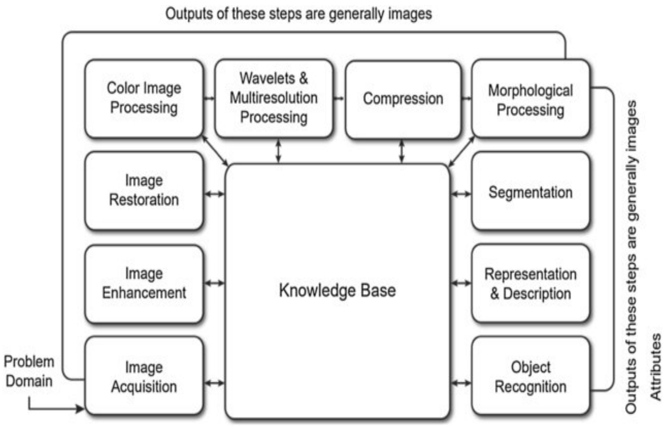

Figure 6. Steps in digital image processing [20]

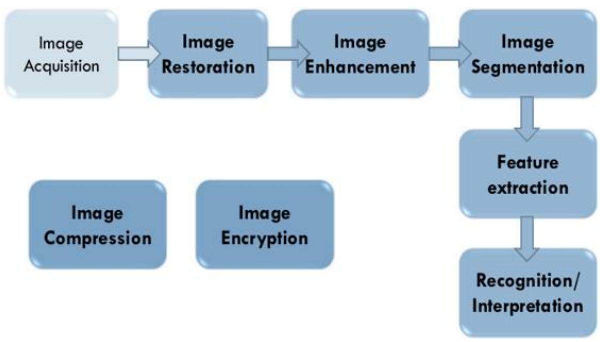

Figure 7. Fundamental block diagram of image processing

3.2.1 Data collection requirement

The data collection is the object for conducting analysis. It was needed to get the extract of coconut shell which has been collected from a coconut shell dump in the city of Accra and also the wood from Afram plains Charcoal's makers which is already a carbon neutral component and will play an important role through the study.

3.2.2 Hardware requirements

The hardware requirements represent the external components to obtain all the images of coconut shell and wood, which permit the analysis. The tools used include:

•IPhone 11, 256gb, 60fps, 12-megapixel (f/1.8) + 12-megapixel (f/2.4) + 12-megapixel (f/2.0)

•Dell laptop, Intel core i7 Random Access Memory (RAM) 16GB.

This describes a phone's camera system with 256GB of storage. It also has the ability to record video at 60 frames per second (fps), and three 12-megapixel cameras with different aperture sizes, indicated by the "f/number" (f/1.8, f/2.4, and f/2.0).

Essentially, it allows for versatility in photography, which includes capturing wide-angle shots, close-up details, and better low-light performance depending on which lens is used at the time.

3.2.3 Software requirements

MATLAB toolbox is the software used here, after acquiring the digital image of the object, it is uploaded it for the analysis.

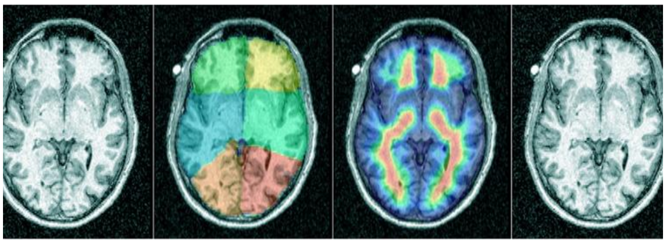

Figure 8. Pattern recognition analysis process

The process of image acquisition is to take a shot of the object which will give the 2D format needed for digital utilization and processing.

Uploading images of the objects in the MATLAB software toolbox means that, certain variables need to be declared for the software for recognition. Variable declaration is the use of syntaxes for the coconut shell and wood in order to identify the two. Then RGB to grayscale is applied to the digital images to reduce the value of the image and also to eliminate all the red, green and blue sets of pixels. Achieving a gray image is important for image processing. The gray image is then enhanced for more clarity and also to improve the quality of the images. This operation highlights the patterns present on the coconut and wood after the syntax is input (Figure 8).

3.2.4 Sample preparation of coconut shell

Coconut shells have an inherent advantage of less prepapration or readiness time before analsysis is conducted, mainly due to its composition, which makes it suitable and compactible to the use of digital image processing methodology. In this research, the coconut fruit samples were washed with clean water to remove any form of chemical contamination, followed by the removal of the fibrous husk to get the initial weight of the coconut shel. One key aspect of the shell samples is that, the kennel and coconut water have been consumed already and the only part appled for this research is the shell. The cleaned samples are then dried further to obtained a desire moisture content for the digital image processing process. The moisture content of the final samples ready for detection is calculated by:

Moisture content (%) = ((Inital weight)-(Final weight)/Initial weight) *100%

Another key consideration in this research is that the dryness level of both wood and coconut shell were the same and that is accurately confirmed from their miosture contents.

Also, the sampling theory adopted in this research is the Nyquist-Shannon theorem, which states that for one to be able to reproduce sampled values, then the sampling frequency (FM) should be at least be twice the highest spatial frequency present in the image to be sampled. Thus, $F_S= 2F_m$, where, F_S is the sampling frequency, and F_m is the image frequency. Essentially, a total of 180 images were captured for processing.

4. RESULTS AND ANALYSIS

Here, the dataset represents the collection of elements granted rights to conduct our research. In an attempt to prove that coconut shell has energy properties and is carbon neutral, various external components have been used to extract some of the morphological features of coconut shell and wood. Another main stage of this project is color, which consists of the conversion of the image color from RGB to grayscale; this conversion will play an important role in obtaining a clear and accurate overview of the object. It will also help to reveal and identify all the patterns present; then, by obtaining the object description we need, we will be able to analyze them and obtain our results.

Notably, every step was represented in the algorithm via MATLAB syntax. The following steps is to constitute the main processes used in our analysis:

It is necessary to note that every step was enshrined in the algorithm by a MATLAB language syntax. The following steps are the main processes used for the analysis.

4.1 Variable declaration

This step consists of renaming input data for the software to identify and then being able to recognize the objects, when the data is needed for processing. The syntax is variables: v1 = {value,'unit'}; end.

Here, the input data for coconut shell and wood are denoted by SH and W, respectively.

4.2 Image display

After declaring the variables (Images), which do not appear directly on the workspace. Another line of code is written for the image to be displayed, and reassures the user of the effectiveness of the data. Essentially, the display of the image indicated the readiness of the analysis using digital image processing techniques.

4.3 RGB to grayscale

Efficiency in image processing attainment requires the image size to be reduced by converting RGB images into grayscale.

4.4 Image enhancement

Reducing the size of an image makes digital image processing easier, but same may also affect the quality of the image, hence, the need to enhance the gray image to eliminate all flaws and to obtain a clearer view of the working area [18].

The gray scales of the image is required for the provision of a good balance between simplified images and added details, which makes it suitable for applying numerous image processing techniques, edge detection, filtering as well as image analysis.

4.5 Thresholding

Thresholding consists of segmenting a grayscale image by changing pixel intensity and applying threshold values. This leads to separating the image into foreground and background values. This value highlights sections of the images to be analyzed. In this research, up to the fifth level thresholding is applied for accuracy in the prediction and analysis.

Command 1: S = imread('IMG_5087.jpeg'); imshow (S), as shown in Figure 9.

Figure 9. Dry coconut shell

Command 2: Sgray = RGB2GRAY (S); imshow (Sgray), as shown in Figure 10.

Figure 10. Gray converted coconut shell

Command 3: Sh = histeq (Sgray); imshow (Sh), shown in Figure 11.

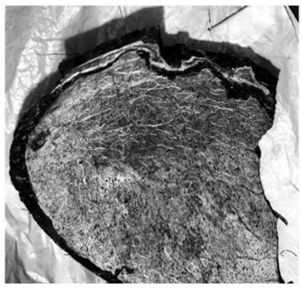

Figure 11. Enhanced gray converted coconut shell

Command 4: level = 0.5; Stresh = imbinarize (Sh,level); imshow (Stresh), shown in Figure 12.

Figure 12. First level coconut shell thresholding

Command 1: W = imread ('IMG_3710.jpeg'); imshow (W), shown in Figure 13.

Figure 13. Charcoal wood

Command 2: Wgray = RGB2GRAY (W); imshow (Wgray), shown in Figure 14.

Figure 14. Gray converted charcoal wood

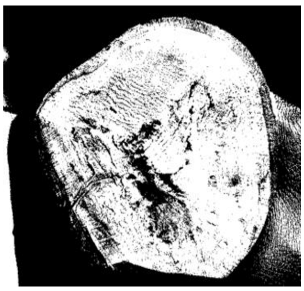

Figure 15. First level charcoal wood thresholding

One of the most important steps in the image analysis is to use the syntax <<Stresh = imbinarize (Sh,level);>> for the coconut shell and syntax <<Wtresh = imbinarize(Wh,level);>> for the wood, this process is referred to as thresholding to create a binary image of the enhanced gray pictures. Threshold values will be input and varied until the pixel intensity of the images accomplished can separate the wanted regions from the unwanted ones. Then, the neural network training tool is activated as a section in MATLAB that performs Pattern recognition, which is the last step in the experiment.

Command 3: level1 = 0.5; Wtresh1 = imbinarize (Wh,level2); imshow (Wtresh2), shown in Figure 15.

Command 4: level2 = 0.6; Wtresh2 = imbinarize (Wh,level2); imshow (Wtresh2), shown in Figure 16.

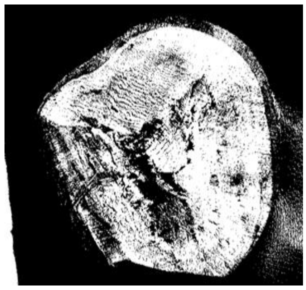

Figure 16. Second level charcoal wood thresholding

Command 5: Wtresh3 = imbinarize(Wh,level3); imshow (Wtresh3), shown in Figure 17.

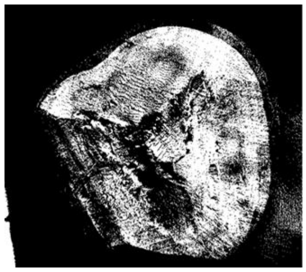

Figure 17. Third level charcoal wood thresholding

Command 6: imshowpair(Stresh2,Wtresh3,'montage'), shown in Figure 18.

Figure 18. Second level coconut shell thresholding and third level charcoal wood thresholding

Figure 19. Fifth letter level coconut shell thresholding and fourth level charcoal wood thresholding

Command 7: imshowpair(Stresh3,Wtresh4,'montage'), shown in Figure 19.

As the images have been inputted, the default of 'Number of neurons' is put into memory. This number is 10 to evaluate the threshold coconut shell image and later add '1' to the default number of neurons to evaluate the threshold charcoal wood image.

4.6 Performance of energy properties

Figure 20 represents the performance of the energy properties of collected images after the thresholding process in Figure 21 is conducted. Figure 20 shows the presence of energy properties of the two images applied. There exists a slight difference between coconut shell and charcoal wood in terms of pattern.

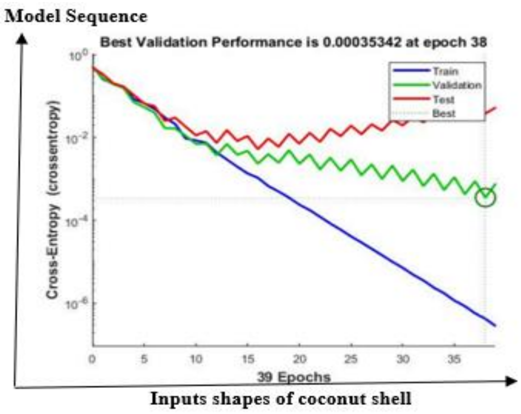

Figure 20. Coconut shell energy properties performance graph

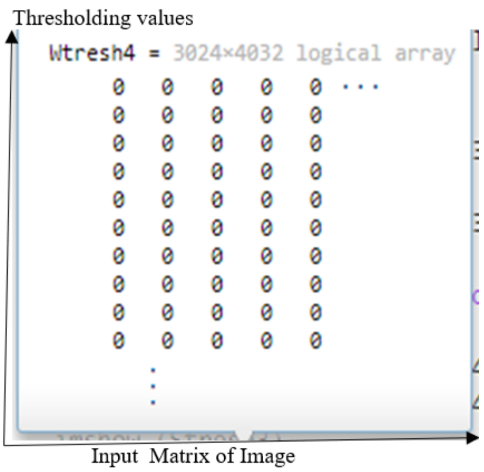

Figure 21. Charcoal wood thresholding matrix

Pattern recognition with MATLAB is basically defined as the process whereby; a received pattern is assigned to one of a prescribed number of classes to operate with the neural network tool.

The syntax for access to that tool is 'nprtool'.

Once the tool is accessed, the pattern recognition application is selected and the 'train' button activated to allow the software to evaluate the output of the written algorithm for the application of pattern recognition.

In both cases, two sets of patterns obtained from coconut shell and a charcoal wood revealed is evaluated by the software to create different analysis matrixes that analyzes the patterns through machine learning system (Figure 22). The different matrixes in the case are as follows:

•Training confusion matrix is a matrix meant to train or apply directly various methods that can be used to analyze patterns.

•Testing confusion matrix is a matrix meant to test directly the method applied compared to other methods that can be used to analyze the patterns.

•Validation confusion matrix is the matrix meant to analyze the performance of the energy properties in the objects directly.

•The confusion matrix obtained is the final matrix displaying the result of the patterns recognition.

The MATLAB code from the dataset loading stage, training and testing stage is as follows.

Stage 1: dataset is loaded on the MATLAB software, in this case a total of 180 dataset consisting of images of coconut shell and 178 dataset of charcoal wood were laoded inturns for the analysis.

Code 1: load coconutshell_dataset.mat

inputs = coconutInputs;

targets = coconutTargets;

Code 2: % Create a Pattern Recognition Network

hiddenLayerSize = 1;

net = patternnet(hiddenLayerSize);

Finally, to achieve results for All Confusion Matrix. For training, a total of 124 dataset is used, the validation and testing stages 28 and 27 dataset respectively. Furthermore, for the analysis of coconut shell, out of 180 dataset which consist of images of coconut shell, a total of 179 were applied for training, validation of testing and 1 was hidden as shown in Figure 22.

On the other hand, for the analysis of the charcoal wood. Out of the 178 dataset which consist of images of charcoal wood. A total of 177 images were applied for training, validation and testing and 2 were hidden as shown in Figure 23.

Figure 22. Coconut shell confusion matrixes

Figure 23. Charcoal wood confusion matrixes

Code 3: % Set up Division of Data for Training, Validation, Testing:

```
net.divideParam.trainRatio = 124/180;
net.divideParam.valRatio = 28/180;
net.divideParam.testRatio = 27/180;
```

Essentially, grouping this dataset and uploading it to the software is important to enable an evaluation of the model's performance on the unseen test data and hence, creating an enabling environment for the provision of an unbiased estimation and generalization ability of the model. The following syntax help with the display of the figures and diagram representing the results for the analysis.

```
% Train the Network
[net,tr] = train(net,inputs,targets);

%plot confusion matrix for training
yTrn = net(inputs(:,tr.trainInd));
tTrn = targets(:,tr.trainInd);
figure, plotconfusion(tTrn,yTrn,'Training');

%plot confusion matrix for validation
yVal = net(inputs(:,tr.valInd));
tVal = targets(:,tr.valInd);
figure, plotconfusion(tVal,yVal,'Valdation');

%plot confusion matrix for testing
yTst = net(inputs(:,tr.testInd));
tTst = targets(:,tr.testInd);
figure, plotconfusion(tTst,yTst,'Testing');
```

Essentially, the values in the threshold matrix shown in Figure 21 indicate a distribution of the matrix elements of charcoal, enabling critical comparison of noise or bias removal in the conducted analysis.

4.7 Results of pattern recognition

The confusion Matrixes for coconut shell and charcoal wood are the results obtained for the pattern recognition analysis conducted to visualise the performance of the two quantities by comparing the prediction labels for coconut shell against the true lebels in this case charcoal wood. The results in the green boxes are called the 'True positives' meaning, the method used to segment patterns for the image is appropriate. Hence, delivering the energy property index at the bottom right boxes. The pink boxes are called the 'True negatives' which indicates that the other methods directly applied were not appropriate to analyze the patterns. Essentially, the diagonal elements represent the true positives and true negatives and the off-diagonal elements are the false positive and negative values. Most importantly, the higher the diagonal values the better performance of the model, thus, the better the prediction process.

Considering Figure 22 for all confusion matrix, the results of '99.4%' of energy property index in the two all confusion matrixes figures for both coconut sheel and charcoal wood is the proof that coconut shell is as carbon based as charcoal wood and a good bioenergy agent. Moreover, the results indicate that, out of a total of 180 samples as a dataset for coconut shells and 178 samples as dateset for charcoal wood in Figure 23. 179 and 177 samples were correctly predicted for coconut shell and charcoal wood respectively, Thus, the overall accuracy of 99.4% was obtained in each case, which is calculation results of the percentage successes of prediction from the overall sample for coconut shell and charcoal wood from the total samples observed.

By applying more than one method to conduct the analysis and writing the corresponding algorithms of coconut shell and wood as well as abiding by the policies and steps involved in this project, a solid backing of the research conducted is provided. The positive results obtained in both cases establishes a convincing assessment of the bioenergy properties of coconut shell as expected and so a pronouncement of coconut shell being a source of energy is duly made.

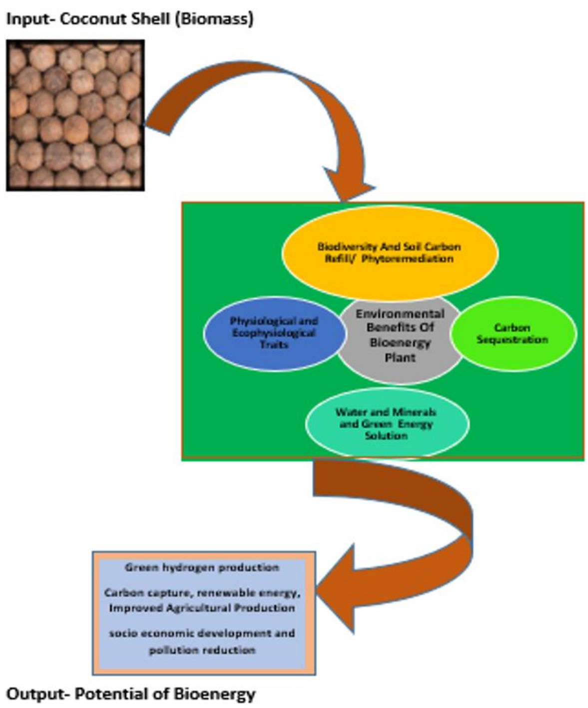

Figure 24. Proposed framework of the potentials of coconut shell as a bioenergy fuel

4.8 A proposed framework of potentials of bioenergy (coconut shell) for sustainability

Generally, bioenergy plants increase soil carbon and fix atmospheric carbon for plant growth, making it essential in the Earth's carbon cycle. Similarly, biomass provides hydrogen, which can be chemically extracted to produce green hydrogen fuels, and can be used for many applications and thus establishing the bioenergy characteristics of coconut shells with great potential in the application of the benefits of bioenergy fuels for energy sustainability in sub-Saharan Africa. Figure 24 illustrates a proposed framework of the potential of coconut shells to encourage waste management and environmentalism for sustainability in the energy value chain in African countries [20].

The proposed model's, input variable is biomass and for that matter coconut shell, the mediating variables include, Soil biodiversity and soil organic carbon refill/ physomeation, which focuces on the need to repairing of the farm land and promotion of soil resilient to plants and animals by making organic material available for renewing plants lives.

Also, if physiological and ecophysiological traits are managed to promote interaction between biomass processes and the environment. Most bioenergy plants will benefit from the environment and there will be sustainability.

Finally, the model has another mediating variables which is concerned with the carbon sequestration process, that involves the storage of CO_2 to mitigate climate change and also the availability of water and minerals and green energy solutions. Ultimately**,** the output of the model will lead to the attainment of green hydrogen production, carbon capture/ renewable energy production, improved agricultural production, socio-economic development and pollution reduction.

5. CONCLUSIONS

CO_2 released during the combustion of biomass is needed for plants growth. Similarly, when crop biomass is used for energy generation, no net CO_2 is generated, this is because the amount emitted during usage has previously been utilized during plant growth. Essentially, the use of bioenergy crops for the production of energy, enables the utilization of alternate sources of renewable energy, which goes a long way into promoting energy sustainabilty and environmentalism.

The focus of this work is to prove that coconut shells have bioenergy properties, essentially to control environmental pollution and to demystify the intuition of many Ghanaian societies about the fact that coconut shells are waste and rather promote recycling and adoption of renewable energy [21]. Thus, digital image processing was employed through a MATLAB model to predict the pattern of the images in both charcoal wood which is known for its energy properties and coconut wood, in order to predict the hidden energy properties of coconut shell (considered as waste). Results from the all confusion matrix, indictae that both samples have '99.4%' of energy property index in both all confusion matrixes figures for coconut shell and charcoal wood, which is the proof that coconut shell is a carbon based material just as charcoal wood and for that matter a good bioenergy agent.

Moreover, the results indicate that, out of a total of 180 samples as a dataset for coconut wood and 178 samples as dateset for charcoal wood, 179 and 177 samples were correctly predicted for coconut shell and charcoal wood, respectively. Thus, the overall accuracy is 99.4% in each case, resulting from the percentage of successful predictions in the overall performance for coconut shell and charcoal wood. This indicates that coconut shells are carbon-based, first-generation bioenergy crops with high bioenergy properties and lower ignition properties compared to charcoal wood.

It is recommended that research to ascertain the hydrogen content of coconut wood should be conducted in order to explore the production of green hydrogen for an overall impact in the attainment of the balance in the supply and demand of electricity in Ghana [21, 22].

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