PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT
2019, vol. 14, no 2, 143-155

Deep Neural Networks for Curbing Climate Change-Induced Farmers-Herdsmen Clashes in a Sustainable Social Inclusion Initiative

Wykorzystanie głębokich sieci neuronowych w ograniczaniu zmian klimatycznych związanych z konfliktem farmerów i pasterzy w ramach inicjatywy na rzecz zrównoważonej integracji społecznej

Emmanuel Okewu*, Sanjay Misra,***, Luis Fernandez Sanz****, Foluso Ayeni*****, Victor Mbarika*****, Robertas Damaševičius******

**University of Lagos, Lagos, Nigeria,*
E-mail: eokewu@unilag.edu.ng
*** Covenant University, Canaanland, Nigeria,*
****Atilim University, Ankara, Turkey*
E-mails: Sanjay.misra@covenantuniversity.edu.ng, sanjay.misra@atilim.edu.tr
***** University of Alcala, Alcala De Henares, Madrid, Spain*
E-mail: luis.fernandezs@uah.es
******Southern University, Baton Rouge, USA*
E-mails: foluso.ayeni@icitd.com, victor_mbarika@subr.edu
******* Kaunas University of Technology, Kaunas, Lithuania*
E-mail: robertas.damasevicius@ktu.lt

Abstract

Peaceful coexistence of farmers and pastoralists is becoming increasingly elusive and has adverse impact on agricultural revolution and global food security. The targets of Sustainable Development Goal 16 (SDG 16) include promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable and inclusive institutions at all levels. As a soft approach and long term solution to the perennial farmers-herdsmen clashes with attendant humanitarian crisis, this study proposes a social inclusion architecture using deep neural network (DNN). This is against the backdrop that formulating policies and implementing programmes based on unbiased information obtained from historical agricultural data using intelligent technology like deep neural network (DNN) can be handy in managing emotions. In this vision paper, a DNN-based Farmers-Herdsmen Expert System (FHES) is proposed based on data obtained from the Nigerian National Bureau of Statistics for tackling the incessant climate change-induced farmers-herdsmen clashes, with particular reference to Nigeria. So far, many lives have been lost. FHES is modelled as a deep neural network and trained using farmers-herdsmen historical data. Input variables used include land, water, vegetation, and implements while the output is farmers/herders disposition to peace. Regression analysis and pattern recognition performed by the DNN on the farmers-herdsmen data will enrich the inference engine of FHES with extracted rules (knowledge base). This knowledge base is then relied upon to classify future behaviours of herdsmen/farmers as well as predict their dispositions to violence. Critical stakeholders like governments, service providers and researchers can leverage on such advisory to initiate proactive and socially inclusive conflict prevention measures such as people-friendly policies, programmes and legislations. This way, conflicts can be averted, national security challenges tackled, and peaceful atmosphere guaranteed for sustainable development.

Key words: climate change, deep neural network, farmers-herdsmen clashes, policies and programmes, social inclusion

Streszczenie

Pokojowe współistnienie rolników i pasterzy staje się coraz mnie realne, co ma negatywny wpływ na rewolucję rolniczą i globalne bezpieczeństwo żywnościowe. Cele zrównoważonego rozwoju (SDG 16) obejmują promowanie tworzenia pokojowych i zintegrowanych społeczeństw na rzecz zrównoważonego rozwoju, zapewnienie wszystkim dostępu do uczciwego wymiaru sprawiedliwości i tworzenie skutecznych, odpowiedzialnych i integrujących instytucji na wszystkich poziomach. W ramach łagodnego podejścia i długofalowego podejścia do problemu konfliktów rolników-pasterzy w kontekście kryzysu humanitarnego, w niniejszym artykule zaproponowano architekturę integracji społecznej wykorzystującą głęboką sieć neuronową (DNN). Formułowanie polityki i wdrażanie programów w oparciu o obiektywne informacje uzyskane z historycznych danych przy użyciu inteligentnej technologii, takiej jak głęboka sieć neuronowa (DNN), może być przydatne w zarządzaniu emocjami. W niniejszym artykule zaproponowano oparty na danych uzyskanych od Nigeryjskiego Narodowego Urzędu Statystycznego system ekspercki rolników-pasterzy (FHES) oparty na DNN w celu przeciwdziałaniu nieustannym starciom rolników-pasterzy wywołanych zmianami klimatu, ze szczególnym uwzględnieniem Nigerii. Do tej pory wiele było ofiar. System FHES jest modelowany jako głęboka sieć neuronowa, przy użyciu danych historycznych hodowców-pasterzy. Zastosowane zmienne wejściowe obejmują ziemię, wodę, roślinność i narzędzia, podczas gdy zmienne wyjściowe to rolnicy-pasterze skłonni do pokoju.

Analiza regresji i rozpoznawanie wzorców przeprowadzone przez DNN na danych rolników-pasterzy wzbogaci mechanizm wnioskowania systemu FHES o wyodrębnione reguły (baza wiedzy). Podstawą tej wiedzy jest klasyfikacja przyszłych zachowań pasterzy/rolników, a także przewidywanie ich skłonności do przemocy. Krytyczni interesariusze, tacy jak rządy, dostawcy usług i naukowcy, mogą wykorzystać takie doradztwo do zainicjowania proaktywnych i społecznie włączających środków zapobiegania konfliktom, takich jak przyjazne dla ludzi polityki, programy i prawodawstwo. W ten sposób można uniknąć konfliktów, stawić czoła wyzwaniom bezpieczeństwa narodowego i zagwarantować pokojową atmosferę dla zrównoważonego rozwoju.

Słowa kluczowe: zmiany klimatu, głęboka sieć neuronowa, konflikty rolników-pasterzy, polityki i programy, włączenie społeczne

1. Introduction

In a bid to improve forecasting capacity of policy makers and service providers in the agricultural sector particularly with respect to farmers-herdsmen conflict, there is need to rely on historical data for knowledge engineering. Qazi et al. (2015**)** opine that knowledge engineering tools like data mining and machine learning are capable of eliciting robust and credible information from historical antecedents for formulating polices, implementing programmes, managing projects and making pronouncements that are equitable and socially inclusive. Once the sedentary farmers and mobile pastoralists have a sense that justice is served through such public instruments, they are likely to be favourably disposed to peaceful coexistence, a sine qua non for sustainable development. The adverse impact of climate change all over the world is also evident in the Lake Chad Basin (Ndehedehe et al., 2016; Buma and Lee, 2016). As nations and development partners such as UNESCO are making conscious and concerted efforts to safeguard the basin, reports have it that rainfall has declined steadily in the last fifty years in the region. Consequently, it has shrunk significantly and cannot sustained livelihoods as in the past. Countries like Chad, Niger, Central African Republic and Nigeria are deeply affected as the ecosystem and economy of the Lake Chad Basin dwindle. The multiplier effect is that herdsmen in this region are migrating in search of greener pasture for their livelihood. As they move southwards, there is competition between them and crop farmers over land, water, vegetation, infrastructure, and other live-sustaining resources, resulting in violent clashes. In extreme cases, lives are lost.

This is a clarion call on government to rise up to task of ensuring that its policies and programmes are not biased but all-embracing so as deescalate tensions between farmers and herdsmen. Apart from demonstrating the political will, the need for data-driven decisions that overtime has been known to be non-prejudicial cannot be over-emphasized (Jeong and Lee, 2018).

Against the backdrop that insecurity in any part of the world should be the concern of all, farmers-herdsmen face-off in Nigeria has attracted global attention in recent times. This is particularly so as the country is grappling with the Boko Haram insurgency (Hamid and Baba, 2014). To this end, this article proffers a soft approach to tackling the menace of farmers-herders violence. The study proposes a socially inclusive and mutually beneficial institutional framework that promotes a sense of justice and peaceful coexistence among farmers and headers. To achieve this aim, public policies and programmes should be formulated based on antecedents rather than sentiments. Historical antecedents as reflected in data can be harnessed for eliciting information and knowledge which policy makers and service providers can base their decisions for optimal outcome. In this regard, the paper proposes a knowledge engineering system christened Farmers-Herdsmen Expert System (FHES) that uses deep neural network (DNN) to extract features and classify behaviours of farmers/pastoralists. Regression analysis and pattern recognition in the DNN culminate in an inference engine equipped with rules (knowledge) that guide ac-

curate prediction of disposition of farmers and herders. Such unbiased and non-prejudicial forecast can be used to consolidate on existing socially inclusive policies and initiate new ones so as to proactively tackle impending conflict.

On the contrary, Tubi and Feitelson (2016) posit that formulating policies based on political patronage and primordial sentiments can escalate social conflicts between subsistence farmers and the nomadic herdsmen particularly in developing economies where infrastructure for ranching and grazing reserves are less developed. This is evident in Nigeria where legislations such as Anti-Open Grazing Law and Open Grazing Prohibition and Ranches Establishment Law have resulted in escalated violence and deaths as some concerned parties feel that the legislations are socially exclusive and justice is not being served (Gwangwazo, 2018).

The remainder of the article is arranged as follows: Section 2 is a literature review and related work; the methodology is discussed in Section 3; in Section 4, the implication of the proposed system for social inclusion and peaceful coexistence of farmers and herdsmen is discussed; Section 5 focuses on further work; in Section 6, limitations of the study discussed and recommendations made; and the study is concluded in Section 7.

2. Background and Related Work

2.1. Climate Change and Farmers-Herdsmen Violence

The Sustainable Development Goal 13 (SDG 13) focuses on Climate Action with emphasis on the exigency of taking urgent action to tackle climate change and its impacts through the regulation of emissions and promotion of developments in renewable energy (Goal 13, 2015); Ndehedehe et al., 2016). Many nations have ratified, domesticated and are presently implementing SDG 13. Another reality is the inextricable link between development and climate. In this light, public sector is enjoined to initiate measures to minimize negative impacts on the environment (Kumara et al., 2018).

Nigeria is one of the countries that have domesticated and enforcing SDG 13. Prominent among government initiatives to tackle climate change and its adverse effects are the setting up of an Ecological Fund (Nwabughiogu, 2017) and the Nigerian Meteorological Agency (NIMET). However, the burden of corruption on the country has made the fund less effective in the attainment of set objectives (Galinatoa, and Galinato, 2013). But for corruption, hopes were high at the country's independence in 1960 that a highly industrialized nation would soon emerge given its abundant human and material resources. It is public knowledge that climate-resilience of developed countries have shielded their citizens from unpalatable consequences of climate change.

Among the many manifestations of the negative impacts of climate change on developing economies is the chronic desert encroachment in northern Nigeria. In its trail are socio-economic fallouts and humanitarian crisis occasioned by the raging farmers-herdsmen clashes that have left many dead. As the desert encroaches, green vegetation depletes, forcing the Fulani herdsmen to flee their traditional base in northern Nigeria to the southern parts with their cattle. As the herders approach southern Nigeria with predominantly subsistence farmers, there is competition for resources. As depicted in Figure 1, the farmer wants the land for his crop while the herdsman insists that his cattle must graze on same land. Crisis erupts and in extreme cases, lives have been lost (Gwangwazo, 2018).

Figure 1. Graphical illustration of the social tension between farmers and herdsmen in Nigeria (Source: This Day Newspaper, 2018).

Though governments at state and federal levels have been fashioning out ways to tackle the problem, military options have been largely used as a quick-fix and reactionary measure (Abubakar, 2017). There is room for more advances in research for diplomatic solutions, soft approaches and long term solutions. Part of policy measures taken so far by some state governments are legislations such as the Anti-Open Grazing Law in Taraba State and Open Grazing Prohibition and Ranches Establishment Law in Benue State (Nwachukwu, 2018). However, these legal frameworks have compounded the face-off between the pastoralists and crop farmers, aggravating existing humanitarian crisis. The reason is that some concerned parties, particularly the Fulani herdsmen feel these measures are not socially inclusive and mutually beneficial (Gwangwazo, 2018). In quick response, the Federal Government has suggested creation of cattle colonies across the states but this initiative has met resistance in some states. Since the Land Use Act of Nigeria concedes power over land to states, the federal government has its hands tied as it can only appeal to states for cooperation (Matemilola et al., 2018).

Table 1. Military operations across geo-political zones of Nigeria

SN	Military Operation Code	English Translation	Geopolitical Zone	States covered	Main Target	Main Motivation of Agitators
1.	Operation *Lafia Dole*	Operation Compulsory Peace	North-East Nigeria	Borno, Adamawa, Yobe	Boko Haram terrorists	To create an Islamic state in Nigeria
2.	Operation *Egwu Eke*	Operation Python Dance	South-East Nigeria	Enugu, Anambra, Imo, Abia, Ebonyi	IPOB (Indigenous People of Biafra)	Self-determination struggle to create Biafra Republic
3.	Operation Crocodile Smile	Operation Crocodile Smile	South-South Nigeria and South-West Nigeria	Akwa-Ibom, Cross-River, Rivers, Bayelsa, Lagos, Ondo, Edo, Delta	Niger Delta Militants, Kidnappers, and Pirates	Fight for resource control
4.	Operation *Harbin Kunama*	Operation Scorpion Sting	North-West Nigeria	Kaduna, Zamfara	Cattle rustlers, Farmers-Herdsmen,	Communal clash
5.	Operation *Ayem Akpatuma*	Operation Cat Race	North-Central Nigeria	Benue, Taraba, Kogi, Nasarawa, Kaduna, and Niger	Farmers- Herdsmen	Struggle for grazing land
6.	Operation *Ruwan Wuta*	Operation Rain of Fire	North-East Nigeria	Borno, Adamawa, Yobe	Boko Haram Terrorists	To create an Islamic state in Nigeria

2.2. Insecurity in Nigeria

The climate change-induced farmers-herdsmen clashes have continued to soar as researchers and policy makers are busy making frantic efforts to bring the situation under control. As part of a quick fix, military intervention such as Operation Ayem Akpatuma (Operation Cat Race) has become necessary in affected areas (Ugwuanyi, 2018). Insecurity in Nigeria is legendary with virtually all the six (6) geopolitical zones affected with one form of insecurity or the other. Table 1 contains details of military responses to the various security challenges across geo-political zones in Nigeria (Abubakar, 2017).

Though such use of brutal force to quell crisis is unavoidable in certain circumstances, there is need to increasingly explore and exploit soft approaches for proactively curbing insecurity. From Table 1, it can be inferred that the military makes conscious effort to domesticate its various operations and make them socially inclusive by code naming its operations using local dialects of respective operational zones. This deliberate policy of soliciting the support of the people is commendable though military option is only a reactionary and hard approach that is less fashioned. Overtime, dialogue and diplomacy have been known to be a viable alternative with great potentials for soothing nerves in a way that promotes justice and peaceful coexistence. As captured by SDG 16 (Peace, Justice, and Strong Institutions), sustainable peace between farmers and herdsmen can only be achieved if there is a pervasive feeling of justice among both parties (Goal 16, 2015). As far as the geopolitical space called Nigeria is concerned, both have a feeling that they have equal stakes in catering for their livelihoods (crop farming and cattle rearing). Hence, government policies and pronouncements based on sentiments rather than historical antecedents will create feelings of social exclusion and escalate existing tensions.

A soft approach that promises long term solution to the climate change-induced crisis is data analytics. Basing decisions such as legislations, policies, and programmes on credible and robust information elicited from farmers-herders' data would eliminate bias and prejudices and therefore promote peace and justice among the farmers and herdsmen.

2.3. Deep Neural Network in Agriculture

Enthusiasts in the agricultural sector are desirous of credible knowledge for informed decision making (Shena et al., 2018). Extracting knowledge from farmers-herdsmen historical data could be done using data science techniques such as statistics, data mining, knowledge discovery in databases (KDD), data warehouse, and machine learning (Ali et al., 2012). Deep Neural Network (DNN) is a high-end predictive data mining technique as well as machine learning tool that is reputed for accuracy in generating knowledge from agricultural data sets (Kamilaris and Prenafeta-Boldú, 2018). DNN relies on regression analysis (function approximation), classification (pattern recognition), and forecasting (predictive analytics) for availing policy makers and service providers in the agricultural sector with robust and credible information from observational data (Lu et al., 2017)**.** Applied to farmers-herdsmen data for example, it has capability for classifying behaviours of farmers and herdsmen as well as predicting their disposition to violence amid scarcity of productive resources such as land, water, and infrastructure. In this sense, historical antecedent can be harnessed for furnishing stakeholders in the agricultural sector

with unbiased and non-prejudicial information. Such credible information can be used for strategic interventionist measures and adaptive solutions in the form of socially inclusive and mutually beneficial policies, legislations and institutions. Therefore, designing a DNN-based learning system such as the Farmers-Herdsmen Expert System (FHES) as proposed in this study will go a long way in promoting peaceful coexistence between farmers and herdsmen given that stakeholders will muster the political will to implement it. Farmers and herdsmen will have a sense of social inclusion, justices and equity as a result of unbiased policies and pronouncements of government based on patterns learnt and information extracted by FHES from operational data. The process involves training FHES sufficiently to attain stability by the neural network prior to deploying it for predicting outcome from future farmers-herdsmen data inputs.

2.4. Related Works

In (Kumara et al., 2018), the research addressed the problem of missed or swapped animals and false insurance claims by proposing deep neural network learning based approach. The approach identifies individual cattle using the image pattern of its nose (muzzle point). This feature extraction and classification initiative leveraged on the realization that animal biometrics is a frontline aspect of computer vision that can aid the registration, identification, and verification of livestock. Deep learning as an embodiment of pattern recognition and cognitive science has been able to recognize species or individual animal using visual features. This is in contrast with existing handcrafted texture feature extraction and the traditional appearance-based feature representation techniques that are incapable of recognizing animals in unconstrained environment. Even in constrained environment, the deep neural network approach outperformed traditional methods of animal identification. Though this study demonstrated the use of deep neural network in resolving identity crisis in animal husbandry, it fell short of mentioning how same technology could be applied to resolve emerging farmers-herdsmen crisis that has impacted adversely on livestock rearing and crop farming.

The work of (Sonawane and Choubey, 2017) focused on crop farming and demonstrated the use of neural networks for value addition in seed processing. The research used artificial neural network to grade soyabean seeds for sale in commercial quantity. The authors observed that the use of computer vision rather than human vision in the visual inspection of soyabean seeds will reduce time delay, minimize errors, and scale up accuracy in the process of grading soyabean seed. Hence their advocacy for a neural network-based automated system. The work further highlighted key parameters used as criteria for evaluating quality of soyabean seeds as well as summarized the use of various machine vision techniques for visual inspection and classification of grains. Despite using neural network to enhance agricultural programme through quality seed management, handling farmers-pastoralists face-off using same technology was not discussed, the main focus of this present study.

Tubi and Feitelson (2016) examined how climate change-induced conflicts between herdsmen and farmers in Isreal's northern Negrev were handled by state institutions. The study used archival data to x-ray conflictive and cooperative interactions between the pastoralists and farmers during the 1957-1963 drought, acclaimed to be the worst in the 20th century. The paper reiterated that climate change is increasingly a security problem that deserves attention of academics and political office holders. Strategic interventionist measures taken by state institutions to mitigate frictions and offer relief assistance were cardinal to the limited level of conflict even though it strengthened the power disparities between the groups. It was observed that the drought impacted conflict and cooperation though violence occurred when herders and farmers lacked previous familiarity. The all-embracing approach of the state institutions and the consequent peaceful coexistence between herders and farmers even in the face of severe drought and attendant limited resources underscores the significance of social inclusion to justice, peace and sustainable development. The paper however did not explore the use of artificial neural network for eliciting robust and unbiased information from farmers-herdsmen data for informed decisions.

The work of (Ukamaka et al., 2016**)** used 135 crop farmers and 72 herdsmen as subjects for conducting the study which focused on the roots and remedies of farmers-herders' conflicts. The farmers surveyed outline causes of conflict as destruction of harvested crops, uncontrolled grazing, destruction of farmland, pollution of water source of community and other unpleasant activities of herdsmen. On their part, the herdsmen identified animal rustling, commercialization of crop residue, inability to access water point, and other factors capable of undermining their livelihood. The authors classified the causes broadly as resource use and structural factors while outlining conflict management strategies adopted as rural institutions and social strategies. However, poor funding and institutional supports were fingered as constraints of successful conflict management. Other constraints are demographic, political, economic, social and cultural orientation. The study did not explore the possibility of harnessing historical farmers-herdsmen data using deep neural network for unbiased and informed decision making geared towards social inclusion of both farmers and pastoralists in policies for justice and peaceful coexistence.

Reuveny (2007) researched the impact of climate change on the environment and implications for migration. The study observed that environmental problems caused by climate change such as drought,

rising sea level, melting glaciers, and desert encroachment can stimulate residents to migrate. For those not yielding to migration, they try to adapt to the problems by staying in place without making efforts to ameliorate them. Yet others stay and make conscious and concerted efforts to mitigate the problems. The author opined that option chosen depends on mitigation capabilities and extent of environmental problems. The work further observed that people in lesser developed countries are more likely to choose the option of leaving affected areas which may result in conflict in receiving areas. Based on his findings, the author opined that there are policy implications for climate change. In spite of the fact that the study did not explore the use of machine learning for eliciting credible information for policy formulation for dealing with climate change-induced conflicts, the findings bear relevance to the Nigerian situation used as case study in this present research. The herdsmen from northern Nigeria are chased by desert encroachment and as they approach southern Nigeria, conflicts erupt between them and the subsistence farmers over agricultural resources.

3. Methodology

The study examined data on estimates of crop hectarage, yield and production made available by the Nigerian National Bureau of Statistics (National Bureau, 2011). These estimates are based on sample survey data gathered from farming households. Also examined is the dataset on livestock as contained in the annual inventory of livestock and estimates of livestock and poultry production. The livestock dataset was obtained from the National Bureau of Statistics and Livestock Department of Federal Ministry of Agriculture and Rural Development (FMARD). Both agencies of government prepared the data based on information gathered from farmers and agricultural sample surveys.

The above datasets are respectively sample sizes of crop farming data and livestock data. The population data for entire farming activities since 1914 when the geo-political entity called Nigeria was created to date is a high dimensional dataset that requires sophisticated and precision-conscious machine learning technique like deep neural networks for real-time data analysis and unlocking of useful information. Except in exceptional cases, patterns in both the crop dataset (Table 2) and livestock dataset (Table 3) indicate that there has been expansion in crop production and animal farming. This is attributable to the diversification drive of the government from a monolithic oil economy to non-oil exports. Agriculture is a key area that the diversification policy is focusing on. The growing farmers-herdmen clash could therefore be linked to competition for resources like land, water, vegetation and implements aggravated by climate change effects like desertification.

However, human vision may not be precise in unlocking potentials in the data for planning purposes. To process the data real-time and unveil hidden and useful information for policy making and project implementation, this paper proposes an ANN-based Farmers-Herdsmen Expert System (FHES) as an intelligent software system that offers advisory to critical and relevant stakeholders in peaceful coexistence of farmers and herdsmen for sustainable development. As a pilot scheme, this technology-driven social inclusion initiative harnesses Nigerian farmers-herdsmen data using ANN for generating robust and credible information and knowledge that guides decision making. This is against the backdrop that decisions based on sentiments rather than antecedents will promote social exclusion, aggravate violent clashes and deepen humanitarian crisis.

Conversely, socially inclusive policies, legal and institutional frameworks based on historical data will galvanize peace, justice and strong institutions as enshrined in SDG 16 (Goal 16, 2015). The ANN assists FHES in learning hidden and useful patterns in farmers-herdsmen data for the purpose of generating knowledge for decision making using regression analysis (function approximation), classification (pattern recognition), and forecasting (predictive analytics).

In modelling FHES, deep neural network (DNN) was used. DNN has input layer, hidden layer and output layer of nodes with the hidden layer made up of many layers of nodes for rigorous and elaborate training of the FHES for purposes of high accuracy in results (Kamilaris and Prenafeta-Boldú, 2018). DNN represents a new paradigm in machine learning and DNN-based FHES will be trained rather than programmed, accounting for high accuracy as programmer's errors and biases are eliminated (Lu et al., 2017).

Gathering and analysis of requirements as well as system design were done preparatory to actualizing FHES. The system was designed using Unified Modeling Language. However, implementation is pending.

3.1. Requirements for Farmers-Herdsmen Expert System (FHES)

Tackling the climate change-induced farmers-herdsmen clashes requires that a non-partisan approach be adopted for conflict prevention and control. Therefore, in formulating policies, implementing programmes, and managing projects that have direct bearing on land for crop farming and cattle rearing, both farmers and herdsmen must be integrated in a fashion that promotes a sense of justices and belongingness. All critical and relevant stakeholders in agriculture are therefore potential users of the proposed expert system christened Farmers-Herdsmen Expert System (FHES). The services that FHES renders to these stakeholders include Enquiries, Regression

Table 2. Estimated area planted with major crops in Nigeria, 2004/2005-2007/2008, source: National Bureau of Statistics

'000 Hectare

Crops	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009
Millet	3,835.58	4,428.18	4,270.00	3,827.61	3,749.60
Guinea corn/Sorghum	3,956.71	4,597.56	4,578.00	4,113.68	4,736.73
Groundnuts	2,152.96	2,265.30	1,666.00	2,336.40	2,636.31
Beans	2,153.51	2,153.49	3,098.00	2,364.89	2,524.58
Yams	2,060.80	2,165.75	1,696.00	2,651.03	2,776.01
Cotton	307.37	301.43	222.00	261.80	374.14
Maize	3,209.20	3,791.95	4,670.00	3,175.92	3,335.86
Cassava	2,570.25	2,790.00	2,659.00	2,983.60	3,126.51
Rice	1,454.57	1,590.37	1,526.00	1,680.76	1,788.20
Melon	532.52	530.65	200.00	503.91	454.24
Cocoyam	296.81	315.47	513.00	421.86	480.75

Table 3. Estimated population of domestic livestock in Nigeria, 2006-2010, source: Federal Livestock Department

Livestock	2006	2007	2008	2009	2010
Chicken (Poultry)	158,216,648	166,127,481	174,433,855	183,155,548	192,313,325
Cattle	16,013,382	16,152,698	16,293,226	16,434,978	16,577,962
Goats	51,208,022	25,488,222	53,800,428	5,677,901	56,524,075
Sheep	32,305,032	33,080,353	33,874,281	34,687,264	35,519,759
Pigs	6,386,866	6,642,341	6,908,034	7,184,356	7,471,730

Analysis Services, Classification Services, and Prediction Services as illustrated in the Use Case diagram in Figure 2.

The actor in the above diagram is generic and represents stakeholders such as government, researchers, and service providers who want to secure information from FHES for informed interventionist measures to tackle the ongoing farmers-herdsmen clashes. Towards achieving SDG 16 (Goal 16, 2015), learnt patterns in farmers-herdsmen experiential data should suggest quantity and quality of lands, vegetation, water and implements that satisfy the needs of farmers and herdsmen.

With the use case *Enquiries*, critical and relevant stakeholders in the agricultural sector shall be able to access real-time online information on government agricultural programmes and crisis prevention/mitigation interventions. For example, policy makers and service providers such as ranchers shall be able to inquire from FHES information on levels of availability of agricultural resources such as land, vegetation, water and implements in the various geopolitical zones and geo-agricultural belts of the country. The unbiased information can be used to guide efficient and effective policies on development of initiatives such as farm lands, ranches, grazing land, and cattle colonies in a way that promotes social inclusion and minimizes social tension.

The *Regression Analysis Services* will be used by stakeholders to model a machine learning function for real world farmers-herdsmen training data. Specifically, FHES shall show the relationship between availability of productive resources such as land, water, vegetation, implements and peaceful disposition of farmers/herdsmen. The essence is to ensure that ANN function sufficiently mimic the statistical function of the live data. This will ensure data fitting between machine representation and real-life statistical features of the historical data.

The classification of farmers and herdsmen and their behaviours is another initiative that can douse tension. The use case *Classification Services* can be invoked when the concern of agricultural stakeholders is to understand behavioural patterns of farmers and herdsmen. Sample question that could be asked here is what infuriates a farmer or herdsman and what appropriate steps should be taken to forestall such.

The use case *Predictive Analytics Services* will enable governments, researchers, and service providers to experiment with future input data with a view to forecasting possible outcomes. In the event that certain inputs indicate possible chaos between farmers and herdsmen, remediation measures can be initiated to forestall humanitarian crisis. This use case will only be functional after the ANN-based FHES has been sufficiently trained, stability attained, and enough confidence built that FHES' predictions will be accurate.

3.2. System and Software Design

Conflict management stakeholders shall rely on FHES to interrogate farmers-herdsmen data for credible information in order to proffer lasting solution to incessant farmers-herdsmen clashes. FHES as an intelligent framework for advisory on farmers-herdsmen peaceful coexistence is depicted in Figure 3 below. We anticipate that FHES will be able to suggest dynamically strategic interventionist measures that is all-inclusive based on patterns learnt from supplied farmers-herdsmen data. This way, the informed decision making process with respect to policies and legislations will galvanize a sense of belonging and fairness rather than social exclusion that fuels crisis.

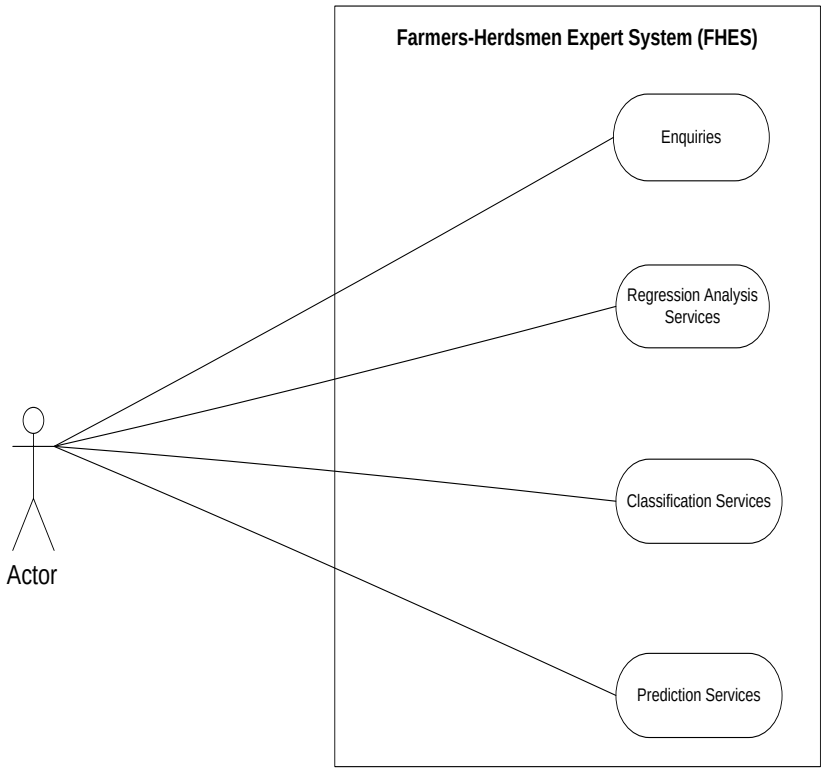

Figure 2. Farmers-Herdsmen Expert System (FHES) use case diagram

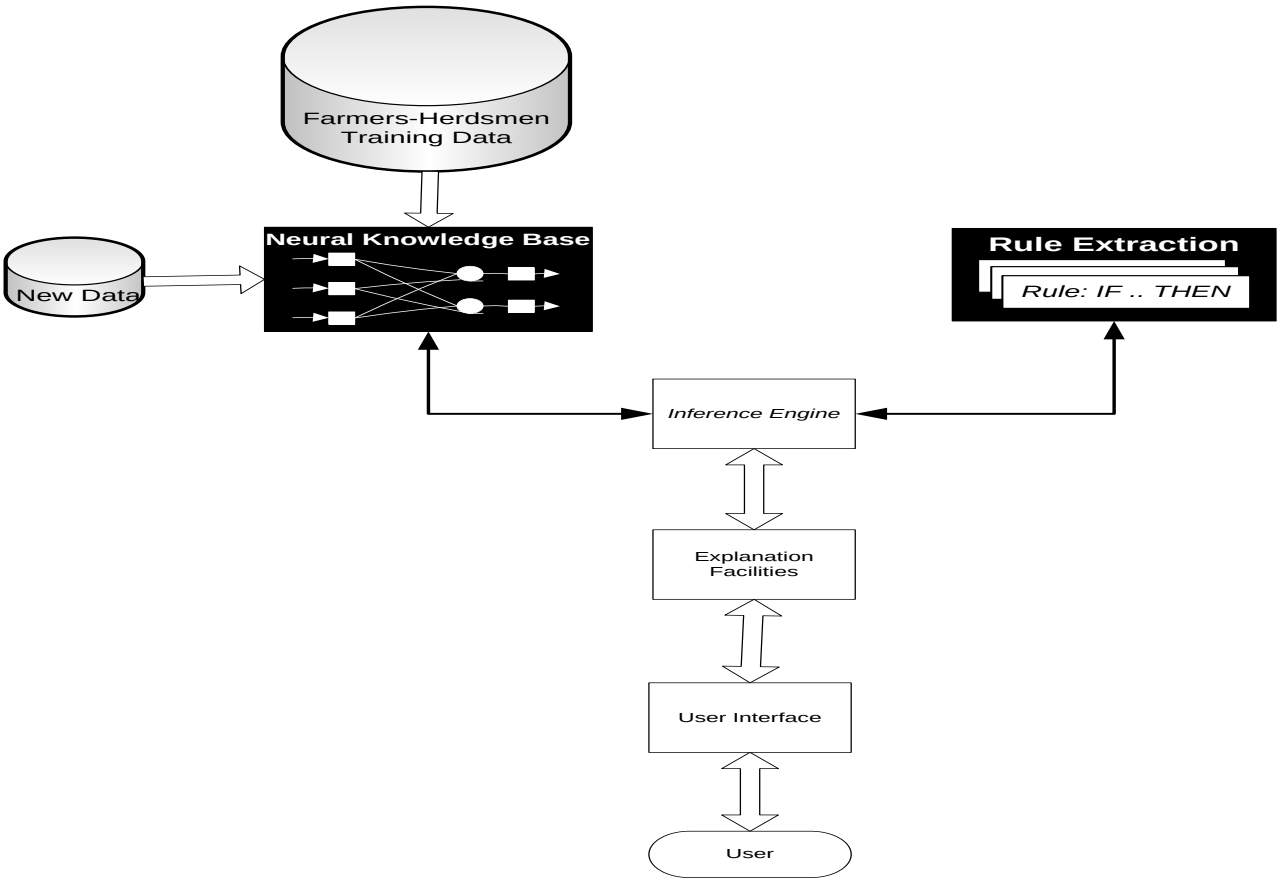

Figure 3. Farmers-Herdsmen Expert System (FHES) design

Table 4. Sample instances of resource distribution and impact on farmers-herdsmen disposition to violence.

Land (x_1)	Water (x_2)	Vegetation (x_3)	Implements (x_4)	Class: Farmers/herdsmen disposition (y)
Sufficient	Adequate	Lush	Available	Peaceful
Moderate	Adequate	Fair	Not available	Peaceful
Scarce	Inadequate	Poor	Not available	Violent

Table 5. Weighted farmers-herdsmen variables

Variables	Linguistic Variables	Weights
Land (x_1)	Sufficient	3
	Moderate	1
	Scarce	0
Water (x_2)	Adequate	1
	Inadequate	0
Vegetation (x_3)	Lush	3
	Fair	1
	Poor	0
Implements (x_4)	Available	1
	Not available	0

As shown above in Figure 3, FHES has both knowledge generation and usage components. The Neural Knowledge Base generates rules (knowledge) using supplied farmers-herdsmen training data and learning algorithm. The extraction and interpretation of rules for decision action is done in the Inference Engine. To foster understanding of system's actions, the Explanation Facilities are used. The User Interface is the channel through which users submit inputs and receive outputs.

Attempts to get coordinated and quantitative observational data on farmers-herdsmen activities from the National Bureau of Statistics of Nigeria for use in this work did not yield result as there is yet to be a coordinated set of data in Nigeria (News Agency, 2018). Hence, the study resorted to hypothetical data as shown in Table 4 which is reasonably representative of the farmers-herdsmen problem.

From Table 4, it can be inferred that the key variables that stimulate violent or peaceful disposition of farmers/herders are land, water, vegetation, and implements. Given that the above data set is used to sufficiently train the network, the proposed system can, based on patterns learnt, forecast the outcome of future tuples such as:

Land = Scarce, Water = Inadequate, Vegetation = Lush, Implements =Available, Farmers/herdsmen disposition = ?

This predictive information can be used by policy makers and service providers to formulate policies and implement programmes that will foster unity and engender peace.

Since deep neural network is purely a quantitative tool unlike other classification schemes such as Bayesian Network and Decision Tree that can process qualitative data, the above data were transformed to quantitative form by assigning weights to respective linguistic variables as indicated in Table 5. The weights were assigned based on their perceived relevance to livelihoods of farmers and pastoralists.

The network (machine) representation of the relationship between the input variables (land, water, vegetation, implements) and the output variable (disposition) is captured in the logistic regression diagram in Figure 4, where x_1 = land, x_2 = water, x_3 = vegetation, x_4 = implements and $\hat{y}$ is the network output.

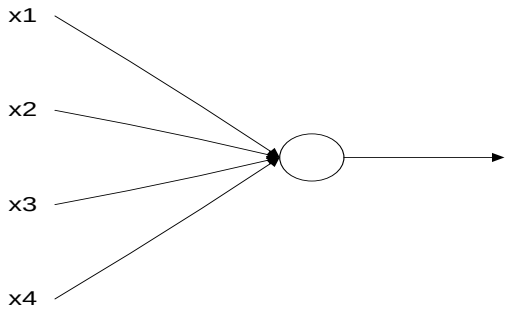

Figure 4. Logistic regression of farmers-herdsmen data

The learning process in the deep neural network commences with an activation function in the artificial neuron as shown in Figure 5.

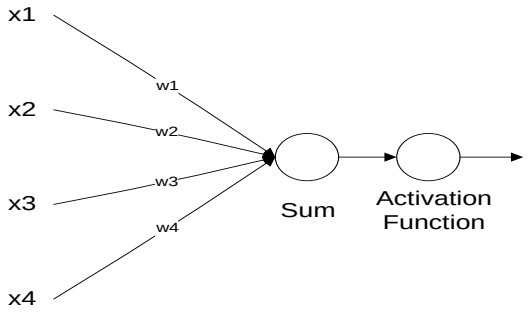

Figure 5. Artificial neuron structure showing learning process

The activation function enables the neuron to learn non-linearity in real world farmers-herdsmen data and also transforms real-valued inputs to probabilis-

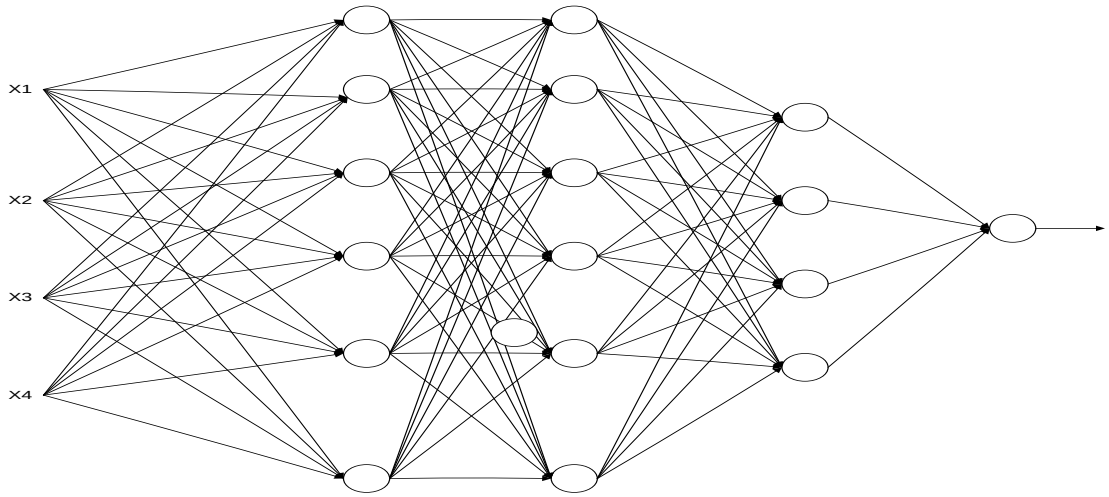

Figure 6. Deep learning of patterns in farmers-herdsmen data for a class of output

tic outputs. The machine learning process is mathematically depicted as follows:

Output of neuron ($\hat{y}$) = $x_1.w_1 + x_2.w_2 + x_3.w_3 + x_4.w_4$

In the event the network output ($\hat{y}$) is not equal to the data (desired or expected) output, an error (cost/loss) occurs. The deep neural network as a self-organizing system, adjusts parameters such as weights and learning rate in continuous iterative refinements until a zero error is achieved or an error size within a tolerable limit. The essence of this learning process, otherwise referred to as perceptron learning rule Dimililera K. and Kianib E. (2017). [25], is to train the proposed expert system, FHES, to correctly classify each instance of the farmers-herdsmen data and it is mathematically denoted below.

$W_{new} = W_{old} + \eta*\delta*X$

where

$\delta = Y - \hat{Y}$

Y = expected/desired output

$\hat{Y}$ = network/actual output

W_{new} = new weight

W_{old} = old weight

η = learning rate

δ = error (cost/loss function)

X = inputs (x_1, x_2, x_3, x_4)

The iterative refinement process of training FHES with successive update of weights is proportional to the derivative of the loss function otherwise referred to as gradient of the error function (Boukis et al., 2009). This is with respect to existing weight in each training iteration. Since the study considered n input variables ($x_1, x_2, x_3, .. x_n$) and m instances ($y_1, y_2, y_3,.., y_m$) for the farmers-herdsmen problem, the learning process can be expressed as a Jacobian matrix of derivatives of loss function as follows:

$$\frac{\partial y}{\partial x} = \begin{bmatrix} \frac{\partial y1}{\partial x1} & \frac{\partial y1}{\partial x2} & \frac{\partial y1}{\partial x3} & \cdots & \frac{\partial y1}{\partial xn} \\ \frac{\partial y2}{\partial x1} & \frac{\partial y2}{\partial x2} & \frac{\partial y2}{\partial x3} & \cdots & \frac{\partial y2}{\partial xn} \\ \frac{\partial ym}{\partial x1} & \frac{\partial ym}{\partial x2} & \frac{\partial ym}{\partial x3} & \cdots & \frac{\partial ym}{\partial xn} \end{bmatrix} = 0$$

When all instances of the farmers-herdsmen data have been correctly classified as depicted by $\partial y/\partial x=0$, FHES is said to have sufficiently learnt and the pattern recognition process concluded. The ANN-based system is then considered to be stable enough for predicting subsequent disposition of farmers/herdsmen from future inputs. Deep neural network modelling of the farmers-herdsmen problem showing vast nodes (neurons) in which the computations take place to correctly classify all instances in a particular category of output (Peaceful disposition or Violent disposition) is shown in Figure 6.

However, since the attitude, belief and behaviour of each farmer/herdsman must be analyzed for a comprehensive, representative and socially inclusive decision making, the mapping of all tuples to their respective classes of output is shown in the deep neural network in Figure 7.

This, in essence, is a comprehensive neural network model of the binary class farmers-herdsmen problem showing mappings from the input vector (X) to output vector (Y).

4. Implications of FHES for Farmers-Herdsmen Clashes

Though statistics of farmers-herdsmen clashes in Nigeria abound (Agbese, 2017), a comprehensive and coordinated database of herdsmen and farmers is lacking (News Agency, 2018). More disturbing is the realization that little efforts have been made towards harnessing such numbers for informed decision making. More often than not, stakeholders in conflict resolution and management base their decisions on mere conjecture, political patronage, primordial sentiments, or just rely on instinct which may not be productive. There is need for a paradigm shift for objective and socially inclusive policies to be formulated for peaceful coexistence of farmers and herdsmen. Proposed legislations such as National Grazing Reserve bill, Open Grazing bill, and Cattle Colony bill for environmental sustainability

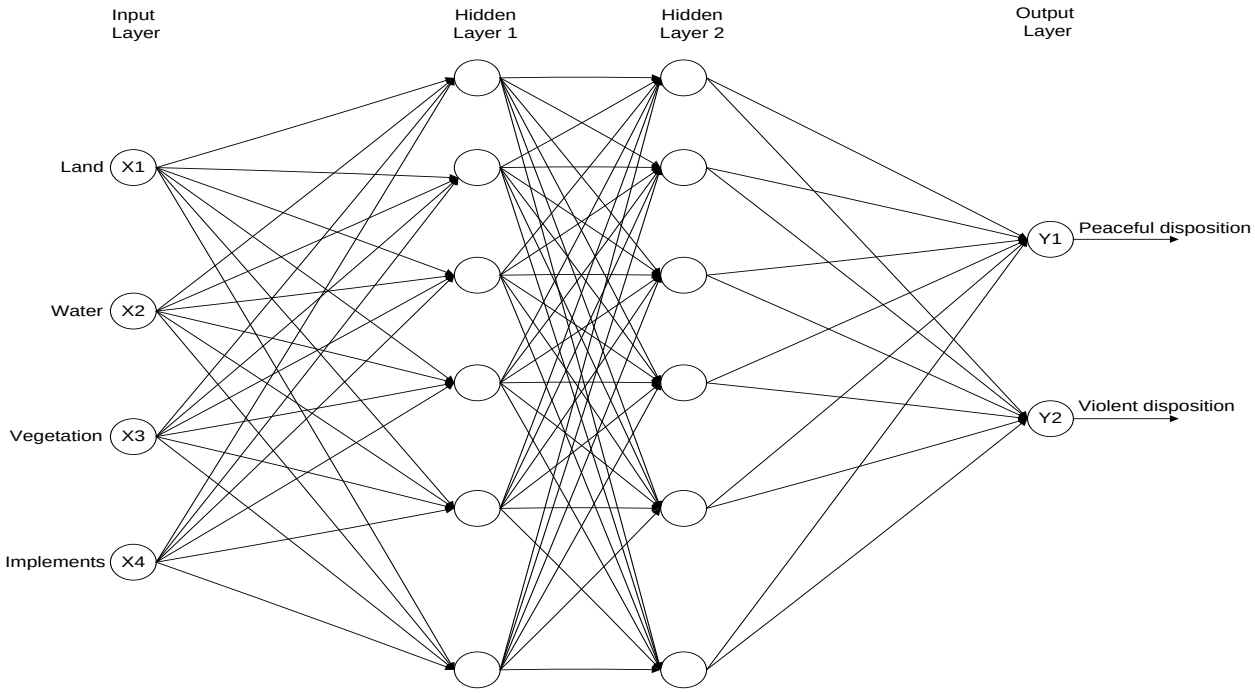

Figure 7. Deep neural network showing binary farmers-herdsmen problem

should be articulated based on historical data or antecedents. This is because there is a strong link between environmental sustainability and economic/national security (Okewu et al., 2018a; Okewu et al., 2018b).

To make optimal use of the database of farmers-herdsmen conflicts, the application of a high-end predictive data mining technique and machine learning tool such as ANN is necessary. The ANN-based learning system, FHES, proposed in this paper is deliberately modelled as a deep neural network to vigorously and rigorously learn patterns in historical data of farmers and herdsmen with a view to offering informed advisory to stakeholders such as government, security agencies, farmers and herdsmen. This is particularly useful in Africa where climate change response system is very weak (Okewu et al., 2017).

If the advisory is heeded, policy formulation, programme implementation, project management, and public pronouncements would be devoured of bias and prejudice. This creates an atmosphere of justices and equity capable of promoting patriotism and sense of belonging thereby mitigating tendencies for violence and conflict. Such proactive crisis management strategy will reduce losses in terms of human and material resources and speed up development across all facets of the SDGs.

5. Further Work

ANN-based expert systems are known to suffer from open problems such as system quality issues, prolonged time of training neural networks, and huge memory requirements. Though advances in research have led to certain improvements, more efforts are required to fully harness the potentials of ANN for optimal decision making in preventing humanitarian crises like those occasioned by farmers-herders clashes. Another area researchers should intensify efforts is reducing the adverse effects of climate change on lives and livelihoods. As depicted in this study by the farmers-herders conflict in Nigeria, scarcity of opportunities (such as occasioned by climate change) and conflicts are inseparable.

6. Limitations of Study

The proposed expert system, FHES, is based on the assumption that adequate, reliable and coordinated data is available. While in developed economies availability and integrity of data are guaranteed, same cannot be said of developing economies such as Nigeria. This can impact negatively on outcomes of data-based studies such as this. Though the Nigerian statistical system has evolved since 1928 providing statistics for national transformation agenda (Olubusoye et al., 2015), obtaining complete dataset for crop and animal farming in Nigeria from 1914 to date is difficult. In any case, the sample data used in this study as obtained from the Nigerian national bureau of statistics offers opportunity for using real-life data for evidence-based policy formulation for tackling farmers-herdsmen conflicts.

Also, typical knowledge discovery in databases value chain requires that pre-processing and processing of data be carried out when knowledge engineering tools are deployed. Though the data used in this study were scrutinized for abnormalities that could impair outcome of the research, some other more advanced studies would have preferred a more

detailed and rigorous data preparation procedure. Nonetheless, the aim of this study is to demonstrate that ANN could be applied to farmers-herders' data to elicit unbiased and non-prejudicial information for policy formulation, programme implementation and project management. Since it has been demonstrated that the proposed ANN-based FHES can promote socially inclusive policies for peaceful coexistence of farmers and herdsmen based of real world sample data obtained from the Nigerian National Bureau of Statistics, it is considered that the aim of system modelling in this paper has been achieved.

Recommendations

1. Countries wishing to implement a scheme such as FHES should have a coordinated data in the form of national database. Presently, many countries, particularly the less developed, don't have such national asset for knowledge engineering.
2. Policy makers and service providers should demonstrate sufficient political will to use the robust and credible output (information/knowledge) from unbiased intelligent systems like FHES for informed and optimal decisions. In this sense, taxpayer resources can be optimally and judiciously utilized in an equitable and socially inclusive manner to promote justice, peaceful coexistence and sustainable development. Conversely, politicization of policies and programmes will breed social mistrust and violence.

7. Conclusion

The humanitarian crisis ignited by farmers-herdsmen clashes may not be peculiar to Nigeria as climate change-induced conditions are found in countries all over the world. However, this study used Nigeria as a case study to proffer a technology-based solution to an environmentally-linked humanitarian crisis. The proposed expert system (FHES) is trained rather than programmed using extracted features of farmers-herdsmen. Real-life farming-related data obtained from the Nigerian National Bureau of Statistics were used to explain the competition between crop farmers and herdsmen for agricultural resources which often results in clashes. A sufficiently trained ANN-based FHES is able to predict crisis-stimulating behaviour based on future inputs using rules in its inference engine. This way, unbiased information is made available to policy makers and service providers for proactive interventions and measures. As a result, socially inclusive policies, legislations, and pronouncements could be made to promote peace, justice, and sustainable development. If the proposed model is implemented, accurate and reliable information can be generated from national database of farmers-herdsmen attributes. An ANN-based expert system does not only classify behaviours of farmers and herdsmen, but is able to predict potentials dangers so that concerned authorities will take appropriate measures to avert the kind of humanitarian crisis frequently experienced in Nigeria.

References

1. QAZI et al., 2015, The artificial neural network for solar radiation prediction and designing solar systems: a systematic literature review, in: *Journal of Cleaner Production*, 104.
2. NDEHEDEHE C.E., AGUTU N.O., OKWUASHI O., FERREIRAD V.G., 2016, Spatio-temporal variability of droughts and terrestrial water storage over Lake Chad Basin using independent component analysis, in: *Journal of Hydrology*, 540, p. 106-128.
3. BUMA W., LEE S., 2016, Investigating the Changes within the Lake Chad Basin Using GRACE and LANDSAT Imageries, in: *Procedia Engineering*, 154, p. 403-405.
4. JEONG D.H., LEE J.M., 2018, Enhancement of modifier adaptation scheme via feedforward decision maker using historical disturbance data and deep machine learning, in: *Computers & Chemical Engineering*, 108, p. 31-46.
5. HAMID A.M., BABA I.M., 2014, Resolving Nigeria's 'Boko Haram' Insurgence: What Role for the Media?, in: *Procedia – Social and Behavioral Sciences*, 155, p. 14-20.
6. TUBI A., FEITELSON E., 2016, Drought and cooperation in a conflict prone area: Bedouin herders and Jewish farmers in Israel's northern Negev 1957-1963, in: *Political Geography*, 51, p. 30-42.
7. GWANGWAZO K.M., 2018, Only justice, fairness will stop Fulani herdsmen, farmers clashes, in: *The Vanguard*, 19 January.
8. GOAL 13: CLIMATE ACTION, 2015, in: *Sustainable Development Goals* (SDGs), United Nations Development Programme.
9. KUMARA S., PANDEY A., SATWIK K.S.R., KUMAR S., SINGH S.K., SINGH A.K., MOHAN A., 2018, Deep learning framework for recognition of cattle using muzzle point image pattern, in: *Measurement*, 116, p. 1-17.
10. NWABUGHIOGU L., 2017, Ecological Funds: NEC approves N2bn each for APC states, in: *Vanguard Newspaper*, May 26.
11. GALINATOA G.I. AND GALINATO S.P., 2013, The short-run and long-run effects of corruption control and political stability on forest cover, in: *Ecological Economics*, 89, p. 153-161.
12. ABUBAKAR I., 2017, Understanding Military Operations as Safeguard of State, in: *The Post*, November 28.
13. NWACHUKWU O., 2018, Umahi heads committee to dialogue with Miyetti Allah, others over Fulani herdsmen/farmers clash, in: *Bussiness Day Newspaper*, February 2.
14. MATEMILOLA S., ADEDEJI O.H., ENOGUANBHOR E.C., 2018, Land Use/Land Cover Change in Petroleum-Producing Regions of Nigeria, in: *The Political Ecology of Oil and*

Gas Activities in the Nigerian Aquatic Ecosystem, p. 257-276.
15. UGWUANYI S., 2018, Benue youths reveal what they fear about Exercise Ayem Akpatuma, in: *Daily Post*, February 21.
16. GOAL 16: PEACE, JUSTICE, AND STRONG INSTITUTIONS, 2015, in: *Sustainable Development Goals* (SDGs), United Nations Development Programme.
17. SHENA Y., ZHOUA H., LIA J., JIANB F., JAYASB D.S., 2018, Detection of stored-grain insects using deep learning, in: *Computers and Electronics in Agriculture*, 145, p. 319-325.
18. ALI L., HATALA M., GAŠEVIC D. JOVANOVIC J., 2012, A qualitative evaluation of evolution of a learning analytics tool, in*: Computers & Education* 58(1), p. 470-489.
19. KAMILARIS A., PRENAFETA-BOLDÚ F.X., 2018, Deep learning in agriculture: A survey, in: *Computers and Electronics in Agriculture*, 147, p. 70-90.
20. LU Y., YI S., ZENG N., LIU Y., ZHANG Y., 2017, Identification of rice diseases using deep convolutional neural networks, in: *Neurocomputing*, 267, p. 378-384.
21. SONAWANE S., CHOUBEY N.S., 2017, A Systematic Literature Review on Soybean Quality Assessment and Utility of Neural Network in Seed Classification, in: *International Journal of Current Research*, 9(05), p. 51160-51165.
22. UKAMAKA M., EDWARD D., SALIFU D., IGBOKWE E.M., 2016, Resource use conflict in agrarian communities, management and challenges: A case of farmer-herdsmen conflict in Kogi State, Nigeria, in: *Journal of Rural Studies*, 46, p. 147-154.
23. REUVENY R., 2007, Climate change-induced migration and violent conflict, in: *Political Geography*, 26(6), p. 656-673.
24. NEWS AGENCY OF NIGERIA, 2018, Umahi orders traditional rulers to compile data on herdsmen, in: *Vanguard Newspaper*, February 9.
25. DIMILILERA K., KIANIB E., 2017, Application of back propagation neural networks on maize plant detection, in: *Procedia Computer Science*, 120, p, 376-381.
26. BOUKIS C., MANDIC D.P., CONSTANTINIDES A.G., 2009, A class of stochastic gradient algorithms with exponentiated error cost functions, in: *Digital Signal Processing*, 19(2), p. 201-212.
27. AGBESE D., 2017, Fulani herdsmen? Here are the grim statistics, in: *The Guardian*, 03 November.
28. OKEWU E., MASKELIUNAS R., MISRA S.,DAMASEVICIUS R., FERNADEZ-SANZ L., 2018, An e-Environment System for Socio-economic Sustainability and National Security, in: *Problemy Ekorozwoju/ Problems of Sstainable Development*, 13(1), p. 121-132.
29. OKEWU E., MASKELIUNAS R., MISRA S., DAMASEVICIUS R., FERNADEZ-SANZ L., 2018, Optimizing Green Computing Awareness for Environmental Sustainability and Economic Security as a Stochastic Optimization Problem, in: *Journal of Sustainability* 2017(9).
30. OKEWU E., MISRA S., OKEWU J., 2017, Model-Driven Engineering and Creative Arts Approach to Designing Climate Change Response System for Rural Africa: A Case Study of Adum-Aiona Community in Nigeria, in: *Problemy Ekorozwoju/ Problems of Sustainable Development*, 12(1), p. 101-116.
31. NATIONAL BUREAU OF STATISTICS, 2011, Annual Abstract of Statistics 2011, Federal Republic of Nigeria, http://www.nigerianstat.gov.ng (1.12.2018).
32. OLUBUSOYE O.E, KORTER G.O., KESHINRO O.A., 2015, *Nigerian Statistical System: The Evolution, Progress And Challenges, Research*, DOI: 10.13140/RG.2.1.3136.4569, https://www.Researchgate.Net/Publication/283715250 (1.12.2018).