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ORIGINAL ARTICLE **ARTS & HUMANITIES**

DECONSTRUCTION OF VIOLENCE IN CHRISTOPHER NOLAN'S THE DARK KNIGHT

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Abstract

In the 21st century, violence has become so abundant and deeply rooted in the visual medium of storytelling known as cinema that it has compelled film researchers to consider violence as a part of cinema's formal structure. Violence being plentiful and readily available to this increasing degree in cinema, it has become a pertinent subject of deep analysis in film studies to decipher all the different implications embedded in the violent acts depicted on celluloid. Christopher Nolan's *The Dark Knight* (2008) is a film that portrays violent tales revolving around the characters of Batman and the Joker. In fact, both heroic and evil characters perform violent acts in the film. Using Jacques Derrida's post-structuralist idea of deconstruction, binary oppositions revolving around violence in the film - such as violence perpetrated by hero/villain, violence in/out of context, justified/unjustified violence - can be analysed. Such analysis of binary oppositions concerning violence can then lead to the discovery of plurality of meaning. As deconstruction aims to uncover the unconscious voices of a text by identifying internal contradictions, binary oppositions or inconsistencies within a text, it is an effective lens to study such complex implications regarding violence. Thus, a single violent act depicted in the film can be deconstructed in different contexts to strip off its singular meaning intended by the filmmakers.

Keywords: Film studies, violence, deconstruction, post-structuralism, binary oppositions

Introduction

As used in many other literary forms of storytelling, violence is often notably employed in cinema as a means of producing conflict, resolving conflict or as a means of portraying stylized entertainment among other purposes. In this manner, violence has always been an integral part of cinema as a means of storytelling. In the 21st century, abundance of deeply rooted violence in this visual medium of storytelling has compelled film researchers to say, "cinema is thoroughly violent" (Slocum, 2001, p. 4); and to also state that violence has become a "part of its [cinema's] deep formal structure" (Prince, 2003, p. 3). Violence being plentiful and readily available to this degree in cinema, it has become a subject of deep analysis to decipher all of its different implications. Christopher Nolan's *The Dark Knight* (2008) is a film that portrays complex violent tales revolving around the DC Comics (American comic book publisher) characters 'Batman' and 'the Joker'. The film sets up a clear binary opposition of hero vs. villain, good vs. evil, positive forces vs. negative forces etc. Nevertheless, characters from both wings of these oppositions perpetrate violence in the film. On surface level, the label of good/evil or hero/villain associated with violent acts renders the function of them as either justified or unjustified. However, these functions and their implications reside only on the surface level of the film. By digging deep into the violent acts depicted in the film and questioning the associated binary oppositions created by the filmmakers, plurality in terms of functions and implications of those acts can be unmasked. As Derrida (1976) defined deconstruction or deconstructive reading in his *Of Grammatology* as an attempt "to make the not-seen accessible to sight" (p. 163), violent acts depicted in *The Dark Knight* can be deconstructed to uncover the plurality of functions, meanings and implications that are beneath the surface level in the film.

Before proceeding any further, a brief discussion is necessary on the issue of defining the boundary of violence in film. Defining the boundary of violence in films is deeply associated with the multiple functions, and in

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turn, multiple forms of violence. As violence can fulfil multiple functions in a film, it can speak to the audience socially, ideologically, geographically, culturally, linguistically and in many other ways. Depending on the particular context or point of view of analysis, violence can assume different forms to serve different functions (Fraser, 1976, p. 9). To perform such different functions, violence varies in terms of type and level of operation such as physical, psychological or even political. Thus, *In Violence and American Cinema*, Slocum (2001) writes, "Harm can be physical, psychological, or even sociological (countering the bonds of community or the state). Even more, the threat of harm or injury can often be as disturbing as the act itself" (p. 2). In this way, Slocum offers a compelling idea of how the threat of violence can have the same disturbing effect on an individual just as the violent act would have. Therefore, this research paper not only dissects explicit and physical violence in *The Dark Knight*, but it also puts great emphasis and importance on the deconstruction of implicit, sociological or psychological violence and the threat of violence in the film. Moreover, the film earned over a billion dollar at the box office (Mendelson, 2019). Therefore, it is imperative to decipher every intended and unintended meaning of the violent actions of the film. Thus, the paper aims to deconstruct violence in the film to decipher all the hidden implications.

Literature Review and Point of Departure

As this study aims to deconstruct violence in *The Dark Knight*, relevant articles and research works have been reviewed to formulate a better understanding of violence and other related aspects portrayed in the film along with identifying research gap and locating a specific point of departure to carry out the research. Dirk Etizen (2013), in his critical essay "Cultural Effects of Cinematic Violence: *Saving Private Ryan* and *The Dark Knight*" explores the violence in the two titular films to decipher its effect on audience's behaviour. Hence, he begins the essay by stating that violent acts on screen "produce changes in our [audience] mental and physical attitudes and dispositions" (p. 3). Etizen's focus is to identify "causal connection between violent thoughts and violent behaviour" (p. 3). Here, violent thoughts refer to the thoughts generated within the audience's mind as a result of watching on-screen violence. This aspect takes his essay towards a study of how human behaviour is influenced by violence in cinema. The focus of his essay is not on how the violence of the film is intended to be perceived by the audience. As *Saving Private Ryan* is not a part of this research, the focus of the review of Etizen's essay will be solely given on his analysis of the violence in *The Dark Knight*.

In his essay, Etizen never quite penetrates the surface level of the violent acts exhibited in *The Dark Knight* barring one part of his analysis where he masterfully brings out a nuanced meaning of the pencil magic trick done by the Joker. As narrated by Etizen, Joker "grabs the gangster's "boy" by the back of the head and slams the head down on the upright pencil. When the man slides to the floor behind the table, the pencil is gone" (p. 10). The film remains silent for the rest of its runtime about the boy and his murder. Etizen extracts a deeper meaning of this silence. According to him, it is done to show that there is "no consequence to the brutal act" (p. 11). Then, he writes, "There is of course a point: the point is to impress. Violence gets people's attention" (p. 11). Here, he tries to indicate that the "people's attention"' in this statement are not merely the attention of the characters on-screen but also the attention of the audience. Thus, he writes, "We do not just soak up ideas of violence from movies. We respond to them, reflect on them, and use them in ways that serve our own interests and needs" (p. 8). These notions about violent acts capturing audience's attention and the audience responding to them are helpful for this research as it can establish the fact that the hidden implications of violence unveiled through deconstruction can also have deep impact on the audience.

Michael Goodrum (2015) studies the relationship between the Batman and the Joker and their unstable identities exhibited in the film *The Dark Knight* in his essay "Joker as Symptom". To explore their relationship, Goodrum suggests that "it is essential to move beyond such categories as "good" and "evil," "hero" and "villain." Both the Joker and Batman conceal their identities, use excessive violence, and—at least in *The Dark Knight*" (p. 229). Even though the essay does not dive deep into the violence shown in *The Dark Knight*, this introduction of Batman and Joker offers an interesting insight for my research purposes. The fact that he introduces the two characters in his essay as users of excessive violence has very deep implication about the acceptance of them in the eyes of the audience. As much as Goodrum tries to move beyond the binary of hero and villain, it is evident that the audience will primarily perceive Batman as the hero and Joker as the villain in *The Dark Knight*. However, the essay never moves forward to analyse the film's violence extensively. Rather, it greatly analyses the unstable identities of the Batman and the Joker in the film created by arbitrary rules of the society. Through the acts of violence, Joker shows how arbitrary the rules of society are within the walls of Gotham (p. 236). In this manner, the focus of the essay shifts from violence.

In the essay "How Can Satan Cast out Satan? Violence and the Birth of the Sacred in Christopher Nolan's *The Dark Knight*", Nicholas Bott (2013) analyses Batman's self-sacrifice in the film using René Girard's mimetic theory. The focus on the issue of violence here is explored in an interesting way by introducing the notion of good violence and bad violence. These two types of violence are defined by him to address the relationship between Batman and Joker in the film. Bott writes, "Their relationship isn't one of good versus evil; rather, they are two sides of the same coin, good violence and bad violence" (p. 245). The two characters being two sides of the same coin is a concept that is heavily associated with the iconic rivalry between the Batman and the Joker. They both commit violent acts but one is labelled as good and the other as evil. Moreover, the usage of good and bad violence is an interesting concept that resonates with how violent acts are accepted or despised according to the effects or consequence they have.

For this paper, Bott's notion of Batman and Joker in *The Dark Knight* being "two sides of the same coin, [who perform] good violence and bad violence" (p. 245) is considered as a point of departure. By disregarding the simplified binary of good versus evil in *The Dark Knight*, he is disrupting the binary oppositions, which is similar to the idea of deconstruction put forth by Derrida. However, he is simultaneously resorting to another binary opposition of good/bad violence. Therefore, in the discussion part of this paper, the researchers have tried to carefully peel off all binary oppositions related to violence to uncover the hidden implications. Bott has demonstrated how surface binary oppositions in the film (such as good vs. evil) can be disrupted. Hence, his idea is taken as a specific point of departure to continue disrupting further binary oppositions to extract more nuanced meaning of violence from *The Dark Knight* through deconstructive reading.

Theoretical Foundation

The notion of deconstruction and some ideas related to violence in film studies constitute the theoretical foundation of this research. The inception of deconstruction as a way of conducting literary analysis is closely associated with the origin of post-structuralism. It was popularized by Derrida during the late 1960s and the early 1970s. In fact, the term was erroneously considered as the first version of post-structuralism in the western world as Hans Bertens (2014) writes, "*deconstruction* . . . was the first version of poststructuralism to reach the United States" (p, 104). However, in a letter to a Japanese Professor, Derrida himself later clarified and created a distance between his notion of deconstruction and post-structuralism (Derrida, 1988, pp. 2-3).

In the same letter, Derrida (1988) also made it clear that for him deconstruction is "not a method" (p. 3). However, from the later part of the 20th century, critics have agreed that deconstruction can be considered as an applicable method by compiling the deconstructive moves Derrida has spread over his many writings and lectures. Norris (1987) writes, "It is not too difficult to come up with a concise formula that would make it [deconstruction] sound like a 'method' and yet describe quite accurately some of Derrida's most typical deconstructive moves" (pp. 18-19). Norris proceeds to describe some of Derrida's deconstructive moves by writing, "To "deconstruct" a piece of writing is therefore to operate a kind of strategic reversal, seizing on precisely those unregarded details (casual metaphors, footnotes, incidental turns of argument) which are always, and necessarily, passed over by interpreters of a more orthodox persuasion" (p. 19).

Thus, deconstructive analysis attempts to break the constrained nature of any text in terms of meaning. It considers the text itself to have a conscious and an unconscious part as the preceding extract suggests. It refers to the fact that any text can involuntarily create doubt for what meanings it is meant to convey by hinting at conscious entrapment of those meanings. Hence, Peter Barry (2013) suggests, "deconstructive reading uncovers the unconscious rather than the conscious dimension of the text, all the things which its overt textuality glosses over or fails to recognise" (p. 68). This particular notion can be seen as an extension of one of the related remarks in *Of Grammatology* that deconstructive reading "attempts to make the not-seen accessible to sight" (Derrida, 1976, p. 163). In the same line of thought, Terry Eagleton defines deconstructive reading as "reading against the grain" or "reading the text against itself, with the purpose of "knowing the text as it cannot know itself" (as cited in Barry, 2013, p. 77). In this manner, the violence portrayed in *The Dark Knight* can be a pertinent subject of deconstruction to unveil different implications lying unconsciously within them. It can bring out plurality in terms of significance from those violent acts at sociological, psychological or political level, which may have been glossed over and smothered by the surface level of analysis.

"Binary opposition" is another key subject in Derrida's idea of deconstructive reading. It denotes a polarity in relationship between two signifiers. Eichner (2001) writes:

> For Derrida, the Western "metaphysics of identity," or the "philosophy of the same," neutralizes the threat of the Other . . . by structuring Western language around a series of binaries in which one member of the pair is privileged, and the other is fixed in a secondary position. The subordinated item of the pair is inevitably conceived only in opposition to the privileged term; (p. 36)

However, in poststructuralist deconstruction, such polarity is often challenged and reversed in terms of privilege (Barry, 2013, p. 71). Thus, the signifiers offer new meanings. To further emphasize the plurality and instability of meaning, Derrida states, "a meaning can never be completely fixed or determined" (as cited in Ijsseling, 1995, p. 96). Meaning is always fluid and subject to change. It may change with passing of time, change of setting, alteration of political scenario, or transformation of individual's perspective. Thus, the changes in meaning to produce this plurality are associated with the term context. Hence, Derrida (1979) writes, "no meaning can be determined out of context" (p. 81). During the production of a text, it can produce one meaning but during different points of reception (by readers or viewers), it can assume different meanings altogether. Thus, meaning is as much dependent on "context of production" as it is on "context of reception" (Bennington & Derrida, 1993, p. 86).

Researchers from the field of film studies echo the aforementioned issue of alteration of meaning based on context as well. In *Film Violence: History, Ideology, Genre*, James Kendrick (2009) directly addresses Film Violence as dynamic and evolving in terms of its meaning with the passing of time and change of where the violence is taking place. He writes:

> Film violence is best understood as a perception, a label that is affixed to cinematic representations of certain behaviours and actions. Film violence is an elastic, sliding, flexible term, one that shifts and changes throughout history and across various cultures. That which is defined as violent in one time or place may not be labelled as such in the future or in hindsight or in another culture. (13)

The elasticity of film violence creates the opportunity to carry out research on a particular film over and over again as its violence can speak to the audience differently in different eras and different settings. In addition, it creates a converging point between the notion of plurality of a text's meaning derived from Derrida's idea of deconstruction and plurality of meaning of violence portrayed on celluloid theorized by researchers in film studies.

Methodology

The research has been carried out utilizing qualitative approach to study violence in *The Dark Knight*. It has been conducted by collecting and analysing non-numerical data to understand the violence exhibited in the film. Hence, qualitative approach is the appropriate one for this study. The design of this research is non-experimental and descriptive as it collects and analyses data by applying content analysis method. The primary source of data in this research is Christopher Nolan's *The Dark Knight*. Relevant journals, articles, books, online sources and film reviews have been analysed as supporting materials supplying the secondary sources of data in this research.

Discussion

In this section, with the aid of previously analysed theoretical foundation, the researchers aim to identify and deconstruct violent acts in Christopher Nolan's *The Dark Knight* to extract different implications of those actions. The background score and musical cues related to violence are discussed along with the deconstructive analysis of the film's significant plot points, lines and actions of the characters.

Violence and Binary Oppositions in Christopher Nolan's *The Dark Knight*

Christopher Nolan's *The Dark Knight* can be simply summarised as a piece of cinema that explores violent conflicts between good and evil, order and chaos, light and darkness, hope and desolation. However, a closer look at the violence portrayed in the film will render this simplification of binary oppositions very much deceptive. The on-screen enactment of violence throughout *The Dark Knight* has much deeper and suggestive implications when these binary oppositions are challenged. There is a clear divide in terms of presentation between the violent acts of the positive forces and the negative forces exhibited in the film.

Before proceeding to the deconstruction of violence in *The Dark Knight*, a brief overview of the plot is included in this sub-section to clearly illustrate the binary oppositions and their supposed disruption in the film. Without pointing out these binary oppositions, the violent acts cannot be subjected to Derrida's way of deconstructive reading. *The Dark Knight* is set in fictional American city named Gotham. Billionaire orphan Bruce Wayne is a resident of Gotham who owns the Wayne Enterprises. He operates as the bat-masked vigilante Batman to fight against crime in Gotham. The city is full of corrupted police and government officials who are in cahoots with the mobsters. As the mobsters can control such officials, it remains impossible for the city to bring them to justice. However, due to the vigilantism of Batman, they have lost some control over the city. Batman has an ally in the form of Lieutenant James Gordon who is one of the few honest police officers left in Gotham. Soon, Batman and Gordon find a new ally with the emergence of the idealist and ruthless District Attorney Harvey Dent. Harvey is also involved in a romantic relationship with Assistant District Attorney Rachel Dawes, a childhood friend and former love interest of Bruce Wayne. With the help of Batman and Gordon, Harvey manages to lock up the entire mob consisting of hundreds of criminals led by Salvatore Maroni. The Joker emerges as an individual with no recorded history in Gotham who wants to bring chaos in the city. He offers the mob a deal that involves him killing Batman and getting half of the mob's money. Initially, the proposal is laughed off but after Harvey locks up the mobsters, they accept it. The Joker starts a killing spree. He murders the judge of the mob's trial and the Police Commissioner. He threatens to kill the Mayor of Gotham as well if Batman does not unmask his true identity. To save Batman's vigilantism, Harvey claims to be Batman. Soon, the Joker is caught by the real Batman as he (J) comes to kill Harvey. However, the Joker is always one step ahead of the curve and manages to kill Rachel and disfigure Harvey's face with the help of his thugs and police officers loyal to the mobsters. An enraged Harvey makes his turn from a heroic figure to a villainous one. He starts killing people responsible for Rachel's death and even kidnaps Gordon's family. However, the Joker is caught by Batman and his (J) plan of destroying order in Gotham is thwarted. Batman also saves the Gordon family. He also takes the blame for the murders committed by Harvey to restore the hope that an honest Gotham official such as Harvey can truly save the city.

The central disruption of the binary opposition between good and evil can be seen in the case of Harvey Dent. Within the course of *The Dark Knight*, Dent's character takes a turn from good towards evil. From being the White Knight of Gotham, he becomes a monster like Joker. Hence, Joker says, "I took Gotham's white knight. And I brought him down to my level" (02:14:53-59). However, Harvey violates law and order to commit crimes during both states. Thus, his violent acts assume different meanings during his heroic stint and his villainous stint. In similar fashion, the violent steps taken by positive forces such as Batman or Gordon is intended to be justified, but those taken by the negative forces are intended to be unjustified and vilified. It is because the binary tail of 'hero' in the opposition 'hero vs. villain' is more privileged. As a result, even the violent actions taken by the heroic forces have a positive meaning on surface level. However, if those actions are viewed outside the binary opposition, a completely new set of meanings can be found which the aim of this paper is. Moreover, such dissection of the binary opposition hero/villain, in turn, challenges the notion of good/bad violence perpetrated by heroes and villains respectively.

A deconstructive study of *The Dark Knight* also shows that violent acts perpetrated by Batman and Joker disrupt the conventional significance of colour associated with good and evil. When Joker blows up Gotham General Hospital, the scene is set with objects in different shades of white only and the Joker is also wearing a white nurse-gown (01:51:55-57). This ties Joker's monstrosity with the colour white which generally represents calm and peace. This disruption is further strengthened by Batman being dressed in black, even though he is intended to be the righteous hero. Another attempt to connect Batman with darkness can be found during the scene showing Bruce and Alfred closing down the secret workspace of Batman. The camera follows them from the back and with every step they take, lights gradually go off and the space becomes gradually darker (01:10:39-48). It signifies that even within the workspace of righteous Batman, darkness resides as he is constantly breaking the rules, as it will be discussed in the following subsection.

Political Implication of Violence in *The Dark Knight*

On surface level, in *The Dark Knight*, Batman and his few yet-to-be corrupted allies in the corrupted law and justice department of Gotham city can be seen as the white knights of Gotham who will put an end to the dark force known as the Joker. However, a closer look at their own violent acts shows how they are not much different from the malevolent Joker in reality. Deconstruction of these violent acts by heroic administrative personnel of Gotham can bring out silent political implications. Batman's vigilantism charms police commissioner James Gordon and the district attorney Harvey Dent so much that they decide to play outside the rulebook of law and justice. In fact, Batman is allowed to trespass into foreign land of Hong Kong to kidnap an accountant named Lau who is working for the Gotham mobsters. As Batman is operating above the law in Gotham, the authority does not question how much he needs to bend the rules to get the job done, as long as he gets the job done. The following conversation between the District Attorney Harvey Dent and Batman highlights this issue:

> HARVEY. We need Lau back, but the Chinese won't extradite a national under any circumstances.
> BATMAN. If I get him to you, can you get him to talk?
> HARVEY. I'll get him to sing. (00:26:54-00:27:04)

Here, it is not a concern of the DA to know how Batman will manage to bring Lau from Hong Kong. Even as a holder of a significant position in the world of law and order, he wants to overlook such violent action of Batman as it will supposedly bring greater good. It becomes a heroic mission to extract Lau from China. From Harvey's perspective the mission involves reconnaissance and espionage. Now, is this trespassing by the supposed American heroic figure into Hong Kong not a political statement? Moreover, the political implication is bolstered by the fact that the tension between the USA and China has been at an all-time high in the 21st century. It certainly becomes such a political statement if the layers of such violent acts are pealed off to extract the political implication. In this way, if geopolitical scenarios are brought to the forefront in order to deconstruct such violent acts, they start to assume new meaning altogether being charged by such geopolitical implications. Moreover, this particular act of Batman is intended to be cheered by the audience as Batman's triumphant theme plays in the background when he flies off with the accountant from Hong Kong (00:37:21-40). During one of the earlier scenes showing Bruce and Alfred planning this mission, it is revealed that the members of flight crew of the plane used to escape from Hong Kong are South Korean smugglers (00:28:44-46). This suggests that taking help from the racket of international smugglers to invade foreign land is also permissible if the intended consequence of such action is good. In this manner, if such violent act of Batman is looked through the lens of geo-politics, it can bring out sensitive and dangerous political implication on a global level. Thus, for this particular violent act, under the surface layer meaning associated with words and phrases such as 'heroic mission', 'espionage', and 'reconnaissance'; there are dormant associations with more sinister words such as 'kidnaping' or 'invasion'.

Social and Psychological Implications of Violence in *The Dark Knight*

Throughout *The Dark Knight*, a common thread runs through statements made by different characters that human beings are inherently violent. During the first meeting between Bruce Wayne and Harvey Dent at a restaurant along with their respective partners, Harvey says, "You either die a hero or you live long enough to see yourself become the villain" (00:20:52-58). Therefore, he implies that the heroes either die a violent death or they themselves resort to violence to become the villain. The line foreshadows the ultimate villainous turn of Harvey Dent in his quest of revenge for the murder of Rachel. In addition, it is a call back to how most of the police officers and members of administration in Gotham have become corrupted individuals far away from their sacred duties. However, a much deeper meaning can be deciphered from the line. That is if the heroes cannot save themselves from being violent after a point, then how the ordinary people can do so as members of the audience.

Moreover, one would assume as it is a film centred around the righteous superhero Batman, it will eventually show that people are inherently good and civilised – not violent. The film does prove the Joker wrong but only partially. Initially, the Joker threatens to keep killing people until Batman reveals his true identity. By doing so, the Joker wants to put an end to Batman's vigilantism as completion of his promise to the mobsters. During the final act of the film, an accountant of Wayne Enterprise named Coleman Reese goes on TV to reveal the true identity of Batman as he had deduced it by looking into Bruce Wayne's expenditure earlier in the film. The Joker perceives that if Reese reveals the identity, he cannot continue his killing spree by using his initial demand of unmasking Batman. Hence, by calling the same TV show, he announces the following message:

> THE JOKER. I had a vision of a world without Batman. [Where] The Mob ground out a little profit and the police tried to shut them down one block at a time. And it was so boring. I've had a change of heart. I don't want Mr. Reese spoiling everything but why should I have all the fun? Let's give someone else a chance. If Coleman Reese isn't dead in 60 minutes then I blow up a hospital. (01:44:11-41)

The Joker knows that his threat of blowing up any hospital in Gotham will create chaos. people who have their loved ones in the hospital will try to resort to violence to kill Reese just as he told Batman earlier that people would lose their civility in such situations. This becomes true as one of the scene shows a mob of people gathering to kill Reese and one person actually shooting him with a revolver as Reese is being escorted by the police (01:45:39-50). This scene ultimately shows the words of Joker to be true. The civilised people of this world are merely one trouble away from being violent to one another. Moreover, the police officer escorting Reese also tries to kill him as he (p) also has a relative at one of the hospitals at that moment. This psychological implication of mankind's eventual turn to violence is explored on the surface level through this event orchestrated by Joker and also by Harvey Dent's remark during his dinner with Bruce Wayne. However, the climax explores this issue on a deeper and wider level.

The climax is setup by the Joker's remark on the violent tendency of civilised people when he is interrogated by Batman. He says, "When the chips are down, these – these civilized people, they'll eat each other" (01:28:47-56). The film does prove the Joker to be wrong but only partially. The Joker uses a violent tactic during the climax of the film. He threatens to take control of Gotham which creates chaos as people try to leave the city. Meanwhile, he takes control of two ferries running in the middle of the river which he had already rigged with explosives. One of the ferries has civilians of Gotham. The other is transporting the prisoners Harvey Dent prosecuted. The Joker pits the civilians against the prisoners by sending the following message to the ferries:

> THE JOKER. Each of you has a remote to blow up the other boat . . . At midnight, I blow you all up. If, however, one of you presses the button, I'll let that boat live. So who's it gonna be? Harvey Dent's most-wanted scumbag collection, or the sweet and innocent civilians? You choose. Oh, and you might wanna decide quickly because the people on the other boat may not be quite so noble. (02:01:01-02:02:21)

The Joker taps into the psychological level of violence. He does not explicitly do anything violent; rather, he creates the threat of violence. He wants the people from the two boats to blow each other up. He wants to bring out the ugliest side of the people of Gotham and prove his point that human beings would gladly start an ugly battle against one another when it comes to their survival. Gotham's civilians decide to practice democracy in their ferry to determine whether they will blow the other boat or not. The pilot of the passenger ferry declares the results, "The tally is 140 against, 396 for" (02:07:32-35). 396 civilians wanted to blow the other ferry up. This is a subtle nod from the film itself that the manifestation of people's violent side during distress is indeed true. It echoes the statement of Joker on how humanity is just one problem away from shedding any sign of humanity left in their soul. However, the film balances this out by showing that none of the civilians on the boat actually has the courage to press the button. On the other ferry, an intimidating prisoner takes the detonator and says, "Give it to me, and I'll do what you should've did [*sic*] 10 minutes ago" before throwing the detonator into the river (02:11:20-36).

Thus, ultimately the film shows that the Joker's plan of bringing out the ugliness of human beings amidst chaos fails due to the goodness left in human beings. However, the film does leave a seed of violence behind to promote it. It is embedded in the voting tally. 73% people on the ferry thought it was alright to blow up a boat full of prisoners. A woman on the civilian boat says, "We don't all have to die. Those men had their chance" (02:02:34-37). She is trying to suggest that her social position triumphs over that of a prisoner and this is what would justify the violent action of killing a ferry full of prisoners. This is how the sociological implication can be extracted from the deconstruction of this violent climactic event in *The Dark Knight*.

Conclusion

As films, such as *The Dark Knight*, that include violence on a large scale, are becoming massively popular among cinemagoers, it is a pertinent issue to analyse the violent acts portrayed in the films from every angular position. The mass circulation of such films is compelling enough to look into the abundance of violence exhibited in them and how different violent acts are functioning differently within the modern society. Through a deconstructive study of the violent acts of the film *The Dark Knight*, the paper has decoded the hidden implications of the violent acts. As illustrated in the discussion section, the violent acts depicted in the film have much deeper significance and function at different levels of operation such as sociological, psychological, or political. At different points of time, when audience consumes the film in a different context, the violence will speak to them with different implications. As a result, future research can be conducted to evaluate how meanings of the film's actions are charged and challenged when the context of production of the film is replaced by the context of audience's reception.

Conflict of Interests

The authors declare no conflict of interest.

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ORIGINAL ARTICLE **ARTS & HUMANITIES**

THE DRONE AND THE BEE: MAN-WOMAN RELATIONSHIP IN G. B. SHAW'S MAN AND SUPERMAN

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Abstract

In *Man and Superman,* which is subtitled *A Comedy and A Philosophy*, G. B. Shaw is basically concerned with the issue of the relationship between men and women. He portrays women as primarily endowed with vital reproductivity and men as endowed with potential intellectuality. Though in this philosophical comedy, he expounds to some length the doctrine of Life Force, he does not attempt to approach the issue in a purely philosophical manner. He contrasts men's intellectualism and romanticism and women's active vitality and practical immorality, and thus his women are motivated to desire men for marriage, and his men either harbour romantic illusions about women or engage in intellectual discussion about man-woman relationship before attempting to escape from the women who are pursuing them for marriage. In the prefatory note to the play, Shaw defends men's intellectual view of this relationship, and as the writer of this comedy, he represents women as if they are the queen bees guided by the Life Force, which forces them to mark out men as their mates and their subsequent victims. The playwright represents men as finally capitulating to such desires of women, though all for the sake of this Life Force, which is purposed to produce intellectually advanced supermen. Though Shaw uses this drone-bee relation as a motif to produce comical effects, with this he both highlights the man-woman relationship and makes it clear that this concept of the Life Force cannot be taken too seriously.

Keywords: Drama, comedy, Shaw, marriage, sex, intellect

Introduction

In his play *Man and Superman*, subtitled *A Comedy and A Philosophy*, G. B. Shaw uses a natural phenomenon of the bees to show how man and woman are attached to each other, and how their relationship works out in practical life. The playwright also uses the phenomenon to support his philosophy which asserts that there should be people who will be very practical and who will always use reason in order to solve various social problems. In nature, the queen bee pursues the drones, which are male, and is also pursued by them, for the sole purpose of mating, and the drone dies soon afterwards as a consequence of this mating. Cruel as it is, this is a strange natural phenomenon, and Shaw has used this in his comedy to highlight his views on man-woman relationship. And since this phenomenon is used in the play several times from the beginning to the end, this can be considered an important motif in the play, which helps the dramatist achieve his purposes of structural cohesion as well as thematic exposition.

This natural phenomenon of the drones and the bee Shaw uses after modifying it with his doctrine of Life Force or creative evolution, where he assumes that women are motivated by the basic concern of sexual union with men and that men are guided by the instinct to escape as long as they can. Shaw's Life Force doctrine not only explains the cruel but natural fact of instinctive sexual attraction but also envisages intellectually advanced human beings, whom he terms supermen. Whereas women for this mating purpose devise the best strategy to enter a marriage, for which they are determined, men either intellectualise or romanticise this relationship, and thus always try to escape from what they consider as enslavement by women. With his Life Force doctrine, Shaw not only represents the late Victorian men and women and their outlooks on love, sex, and marriage but also presents his idea of the supermen who are meant for the perfection of the human race. In so doing Shaw uses the drone-and-bee

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motif to represent men and women; however, he never allows his readers to forget that what they are reading or seeing is a comedy.

Discussion

G. B. Shaw in his play *Man and Superman* makes several references to the bees, which carry different significations, but most importantly he refers to the natural phenomenon that the drone dies after being pursued by the queen bee and after mating with her, as if it is the queen bee that has killed the drone after the purpose of reproduction is served. In the Epistle Dedicatory of the play, Shaw expresses his fear that the Englishman even with his "vital qualities" may not be saved from being "smoked out", and thus be deprived, by more intelligent beings, which is a phenomenon common to the bees (p. 17). However, Shaw is actually after both English men and women, who foolishly pursue money and husbands respectively. He argues that woman "must marry because the race must perish without her travail", and reminds us that "the force that carries women through all these perils and hardships, stops abashed before the primnesses of our behavior for young ladies" (p. 20). Shaw makes another reference to the bees to point out that English people work with instincts only, "not reasoning about the matter at all", which is why as a playwright he is for the intellectual supermen (p. 109). Though Shaw also refers to the spiders to point out that "the spider kills her mate", i.e., the female one kills the male one, "the destined prey", after the mating purpose is served, it is the bees which the playwright refers to more than the spiders (pp. 92, 107).

Shaw thus makes his protagonist Jack Tanner aware of the destiny of the drones who are pursued by the queen bees to mating and death, but his intention is to let the hero accept this reality for the sake of the birth of superman. In Act I, Tanner tells Octavius Robinson to read "Maeterlinck's book about the bee", and thinks that Octavius is "the pursued, the marked down quarry, the destined prey" of Ann Whitefield, the heroine of the play (pp. 90-91). Later in the same Act, Tanner warns Octavius that women can and should kill the worthless men and that they "would kill us as the spider kills her mate or as the bees kill the drone", a phenomenon when the drones, that do not mate with the queen bee and consequently die, are killed by the worker bees, which are female. However, when Tanner learns that it is he who is being pursued by Ann, he exclaims: "Then I – I am the bee, the spider, the marked down victim, the destined prey" (pp. 91, 107). With this motif of mating between the drones and the queen and the killing of the drones, Shaw illustrates how he handles the question of sexual union between men and women, its purpose as well as its consequence – the production of the supermen, but at the cost of men. Shaw's use of this drone-and-bee motif reflects the main aspect of his comic portrayal of man-woman relationship in the play.

Shaw's concept of the evolution of man and woman forms the basis of how man and woman are peculiarly related to each other. According to E. Bentley (1947, Chapter 2), Shaw exploits and restructures Darwin's theory of evolution, and in the Hell Scene, which is the subconscious deliberation of the characters in Act III of the drama, the playwright expounds his theory of creative evolution. Don Juan is the subconscious counterpart of John Tanner and the spokesman of the dramatist himself. Juan observes that "in the evolutional process [woman] invented [man], differentiated him, created him in order to produce something better than the single-sexed process can produce", and thus man is woman's creation so that man can be woman's "contrivance for fulfilling Nature's behest in the most economical way" while the woman is "Nature's contrivance for perpetuating its highest achievement", the continuation and amelioration of mankind on earth (p. 147). However, Shaw is being critical of Darwin's theory, which can be seen in his description of Roebuck Ramsden, the elderly man of affluence, whose views were always opposite to Tanner's, despite the fact that Ramsden, born in 1839, was "an Evolutionist from the publication of the *Origin of Species*" in 1859, and "has always classed himself as an advanced thinker and fearlessly outspoken reformer" (pp. 41-42). Shaw in this play is "seeking to offer a radically different view of evolutionary theory, namely one that would rescue the claims of individual moral responsibility from the ethical chaos of Darwinian natural selection" (Griffith, 1993, p. 126).

The drone-bee relationship articulates the female pursuit of a male for mating purposes and his ultimate vanquishment after her reproductive goal is achieved and Shaw's Life Force doctrine parallels this drone-bee relationship; however, Shaw's doctrine rises above mere drone-bee relation with its higher purpose, the birth of a superman, who is powerful not due to his physical might but by virtue of his intellectual strength. Shaw's Life Force doctrine applies equally to the drones and the bees, or the spider and her mate, or the animal kingdom in general, but he has reserved it for humankind, for he seeks to see that an intellectual superman is born. In other words, while mankind cannot defy the power of nature, i.e., the natural instinct of sex, Shaw wants them to be intellectually strong so that they can solve various social problems, one of them concerning the roles of men and women before and after marriage. Since marriage is a socially and religiously acceptable institution, Shaw has made his characters revolve around this question of marriage, and for this, he has chosen the Life Force doctrine which parallels the drone-bee relation but goes beyond the concept of supermen. Yet Shaw makes his male characters run away wildly in order to escape from this female pursuit which they consider as devastating, even with the prospect of marriage. This female pursuit of men continues till the end, and the comic effects arise through the male characters' frantic attempts to escape. And only in the Hell intermezzo of Act III does Shaw expound his Life Force theory through his subconscious spokesman Don Juan, and by doing so he deviates from the drone-bee relation and its catastrophic consequence for males and thereby adds to it a new, productive dimension with the prospect of the birth of supermen.

Moreover, in this Hell Scene or inner play of Act III, Shaw attaches to the Life Force a religious tone, as he makes his Don Juan think of returning or going to Heaven because "there is the work of helping Life in its struggle upward", which is joy enough for an intelligent man. Not only that, Dona Ana too has to utter: "I believe in the Life to Come. [Crying to the universe] A father! A father for the Superman!" (p.173). Shaw has never mentioned Darwin's name in the play itself, nor has he directly referred to the "evolutional process" but once or twice; yet it is to be deduced that in his conception, Nature has a creative design as well as a controlling power (p. 147). Yet the playwright has mentioned evolution not in the words of Jack Tanner, his protagonist, with whom he starts and ends the comedy, but in the words of Don Juan, who is but a subconscious character in a dream. G. W. Knight observes in this regard that Shaw's belief in the Life Force is characterized by an affirmation of "an optimistic recognition of its miraculous nature as it travails to create a greater humanity" (1962, p. 343).

However, this succinct theorization amply reflects the essence of the relationship between man and woman where a woman takes the active role in satisfying Nature's demand by utilizing man. Don Juan argues that both man and woman, the "helpless agents" of the "universal creative energy", attain manhood and womanhood not by love, as is said by most people, but by the birth of moral passion (p. 161). Jack Tanner contends that, "It is the birth of that passion that turns a child into a man", and that "the first duty of manhood and womanhood is a Declaration of Independence" so that the contemptible subjection of youth to age can be eliminated (pp. 73, 97). This self-contradictory affirmation and negation of morality in relation to attaining manhood and womanhood is neutralized in Tanner's statement that motherhood is a woman's "solemn initiation into womanhood", when the emphasis is laid on reproductivity in line with the philosophical core of the play (p. 82). Echoing Tanner's theory of creativity, which is based on men being victims to women for reproductive purposes, Juan maintains that a man and a woman have no bond between them but a possibility of that fecundity for the sake of which the Life Force has thrown the man and the woman into one another's arms.

The woman is thus depicted as the agent of Nature, i.e., the Life Force, in the continuation of creation. So, she is endowed with vitality, the latent strength for active creation, for which she is programmed to take the initiative, the active role. Tanner asserts that "Vitality in a woman is a blind fury of creation"; and in describing Ann Whitefield, the heroine of the play, Shaw comments, "Ann is one of the vital geniuses" (pp. 54, 60). Early in the play, Tanner admits that the "creative instinct" has led Ann to attach him to her, and later, he argues that because of this creative motive in women, "a man is nothing to them but an instrument of that purpose" (pp. 61, 70). So, Tanner flees from Ann ultimately to be caught by her when he will realize the necessity of transforming his knowledge into action and demonstrating an impression that his becoming a victim of the woman and the Life Force is somehow indispensable and inevitable. While this is the curve chiseled by Shaw in his formation of the Ann-Tanner relationship in the main plot, the Violet-Hector relationship of the sub-plot is also introduced early to reflect in practical light the protagonists' relationship. Tanner's approval of Violet's early activation in wedlock of her vitality to fructify Nature's will and to fulfill her own "highest purpose and greatest function – to increase, multiply and replenish the earth" has to be consolidated in his own alliance with Ann with a greater possibility (p. 64).

Though love is not made obvious in playing a great role in the Violet-Hector relationship, its importance is made manifest in the Ann-Tanner relationship. Tanner admits to Ann that their childish agreement of confidence was "an unconscious love compact" and asserts before Octavius, who is blindly and helplessly in love with Ann, that he himself is in love with Ann but is "neither the slave of love nor its dupe" (pp. 75, 91-92). Tanner's love for Ann is professedly moral and subconsciously sexual as is evident in his harping on the sex instinct of women and men's attachment to them. Juan, however, negates love's importance in the relationship between men and women as he remembers his mundane amoral encounter with Dona Ana and reflects that "It was not love for Woman that delivered me into her hands: it was fatigue, exhaustion" (p. 165). Tanner on earth, i.e., in the waking state, however, has a comprehensive view of love as is expressed in his final protestation of love for Ann in which he says that he loves her because the "Life Force enchants" him (p. 205). Thus, it is sex that is emphasized more than love in the relationship between the male and the female characters of the play.

The relationship between a man and a woman, according to the play's philosophy, should be aimed at producing not mere children but supermen. A superman is, Juan explains, "the ideal individual" who is "omnipotent, omniscient, infallible, and withal completely and unilludedly self-conscious: in short, a god" (p. 149). Brain or intellect is the fundamental characteristic of a superman and this is the "darling object" of the Life Force (p. 150). "Life's incessant aspiration to the higher organization, wider, deeper, intenser self-consciousness, and clearer self-understanding" is destined to produce the superman, and the process is to be materialized in the sexual relationship between the vital woman and the "philosophic man" who is the "only one sort of man [who] has ever been happy, has ever been universally respected among all the conflicts of interests and illusions" (pp. 151, 165). Realizing that Juan's philosophy of the Life Force is not what she earlier termed as "libertine", Dona Ana selects him as the father of the superman she wants to give birth to and cries after him, "A father! a father for the Superman!" (pp. 161, 173). Man has become, according to Juan, "too imaginative and mentally vigorous to be content with mere self-reproduction" because his brain has become extraordinary as a result of the superfluous energy saved him by a woman from the straining labour of gestation (p. 148). Juan also admits that it is women who are responsible for his "astounding illumination" which is the correction of his intellectual reasoning, "I am; therefore I think" not "I think; therefore I am", so that he no longer remains a "foolish philosopher" which he was on earth (p. 154).

The relationship between the hero and the heroine, Jack Tanner and Ann Whitefield, and their subconscious counterparts, Don Juan and Dona Ana, is characterized by pursuance, and it is the women who pursue and it is the men who are pursued. The idea that a woman dangerously waylays and enmeshes her husband for fertility's sake was first formulated by Arthur Schopenhauer and Friedrich Nietzsche and first dramatized by August Strindberg, but this idea was made innocuous by Shaw who, as R. Brustein shows, adapts the Don Juan legend to the legend of Venus and Adonis, and thus, to prevent misgivings of Romanticism in the play's intellectual Victorian context, "adapts both legends to Shavianism, arguing that the whole comedy is played out for a higher purpose, the eventual evolution of the Superman through eugenic breeding" (1991, p. 214-215). And this higher purpose of "the Shavian Life Force is the means of freeing the intellect from its corporeal bonds, of defeating this dichotomy of body and brain" (Berg, 1998, p. 148), the result of which is the birth of supermen.

Both Juan and Tanner believe in the vitality of women, which impels women to pursue men so that Nature's purpose can be fulfilled. As Don Juan with his doctrine becomes able to convince Dona Ana of the "great central purpose of breeding the race: ay, breeding it to heights now deemed superhuman", Dona Ana in order to beget a superman pursues Don Juan who earlier on meeting her in hell protested, "I do not pursue you" and who now says, "I can find my own way to heaven, Ana; not yours", with which he means that she has to realize the need herself (pp. 129, 160, 170). Ann Whitefield, in cogent contrast with Dona Ana, does not pursue Jack Tanner for giving birth to children or supermen. Tanner's talking about Life Force has little significance to her; she comically says, "I don't understand in the least: it sounds like the Life Guards" (p. 203). She is interested not in Tanner's "moral passion" but in "the other one", the passion of love which is the basis of what Tanner has just termed as their "unconscious love compact" (p. 75). It is the male protagonists who are highly conscious of the purpose of Life Force and the greater potentiality of women in this regard and thus intellectualise about these, yet they fly from the female protagonists who must pursue men whether or not they themselves are conscious of the purpose of Life Force and their own vitality.

Ann Whitefield is not, according to R. Brustein, "the dominating, amoral and conscienceless *belle dame sans merci* of the Romantic agony, but rather the independent, intelligent, and well-mannered gentlewoman of the Victorian imagination" (1991, p. 214). She disposes of Ramsden and later of Octavius so that she can court Tanner with full liberty, and such conduct of hers does not conflict with Tanner's moral passion since it smacks not of her intention and since it is deliberately made to look natural. Though Juan's statement that "a woman seeking a husband is the most unscrupulous of all the beasts of prey" reflects Tanner's conviction, Ann is a practical woman who knows the significance of what Tanner calls her "confounded hypocrisy", and thus she says, "Women who are not hypocrites go about in rational dress and are insulted and ... then their husbands get dragged in too, and live in continual dread of fresh complications" (pp. 156, 200, 204-205).

Ann is considered to be one who "feels constrained by the mores of her time, by the passive, dependent role imposed on women then, to hide her will and purpose, and to use guile and trickery to achieve her goal" (McInerney, 2013, p. 194). However, Violet Robinson, Octavius' sister, does not, unlike Ann, resort to hypocrisy; she only conceals her husband's name since it is her husband's desire. Shaw comments that "She is not a siren, like Ann" (p. 81). But Ann's reason for hypocrisy is that she cannot express straightforwardly that she loves Tanner, not Octavius; she is timid and she argues that "All timid women are conventional: we must be conventional, Jack, or we are so cruelly, so vilely misunderstood" (p. 96). Her foreboding comes true even after her pursuit of Tanner to the "romantic reveries" in the Sierra of Spain (p. 155).

The other device Ann utilizes is her charm. Tanner himself experiences that strength of hers and realizes the necessity of Ann's fascination for his meaningful existence as he admits that "there is a sort of fascination about you. ... I should miss you if I lost you" (p. 69). Yet he later blames her for "habitually and unscrupulously" using "her personal fascination to make men give her whatever she wants" (p. 199). Shaw comments in the stage direction that "some magnetism in her draws him to her, a broken man" (p. 202). But men also employ these techniques to win women. The statue of Don Gonzalo admits that he was a hypocrite on earth and that he had some romantic phrases he always used in seducing women. When in the final act Tanner indirectly praises Ann's beauty and Ann demands to know why he tries to fascinate her if he does not want to marry her, Tanner replies, "I am in the grip of the Life Force" (p. 203). "Whatever his intellectual understanding of the Life Force may be, his embrace of Ann is a capitulation to the sexual attraction she exudes" (Dukore, 2009). Tanner, ultimately, has to succumb to his fate of the drone, being pursued and caught, if not vanquished.

Despite their knowledge of the necessity that human life is to be continued and improved to the superhuman level, both Tanner and Juan, who are Shaw's conscious and subconscious representations respectively, fight against what they consider enslavement by women. They have their own reasons which are less practical than the purposes they are conscious of, and they have their eventual defeats too. It is the women who may be said to be "enslaving" men because on them is imposed the greater responsibility, and Tanner makes this point explicit in the question he poses to Octavius: "how can so feeble and transient a folly as a man's selfish pleasure enslave a woman as the whole purpose of Nature embodied in a woman can enslave a man?" (p. 61). Tanner believed that Octavius was being pursued by Ann, and he told him so; yet when Tanner is set aright by Straker, he exclaims, "Then I – I am the bee, the spider, the marked down victim, the destined prey" (p. 107). Tanner has already accused Ann of fighting "harder than anybody against my emancipation", his attainment of "self-consciousness" in the process of his becoming a man (pp. 76, 148). Tanner imagines that his servitude to Ann would relieve other husbands when they see the arrival of a new prisoner who will share their humiliation, the young men will scorn him as one who has sold out, and the women will consider him "merely somebody else's property – and damaged goods at that" (p. 203).

Juan, on the other hand, refers to the legend of Don Juan's sexual escapades, and since he is Shaw's Don Juan, he observes that he has already bitterly experienced that the conquering women always regarded him as their property, and he argues that he became "famous for running away from" them only to escape "lifelong servitude" (pp. 153, 164). As Tanner relishes being "an enigma and a possibility" to the other women, so Juan fears that being cut off by a single woman from "all natural and unconstrained intercourse with half my fellow creatures would narrow and warp me" (pp. 162, 203). But defeat and servitude of such natures are depicted in the play as customary and inevitable, as Tanner observes that "men let themselves be hanged without a struggle", and that he himself has a "frightful feeling that I shall let myself be married because it is the world's will" (pp. 202-03). However, more than the "world's will", it is the Life Force which compels men to resign to such a fate, as Shaw's comedy suggests. Juan admits that in his act of escape from a woman on earth, "Life seized me and threw me into her arms", and Tanner realizes that he must love Ann because he is in the grip of the Life Force (p. 155). It is the Life Force which compels enlightened Dona Ana to chase Don Juan to heaven. Life Force cannot let men make the mistake of flying from women even though they have the knowledge of its sublime procreative function.

The importance of romance in the relationship between men and women is not overstressed in *Man and Superman*; in fact, it is depreciated time and again, which is understandable since Shaw has used the drone-bee relation as well as his Life Force doctrine. Tanner no longer savours his childhood "romantic tomfoolery" with Rachel Rosetree and regards vitality and bravery as the greatest qualities a woman can have (pp. 71-72). Violet's caution to Hector that he can be romantic about love but in no way romantic about money only places money above love in her conjugal life. Tanner warns the lovelorn and poetic Mendoza, who has degenerated into a brigand because of his fruitless and unrequited love for Louisa Straker, that he is sacrificing his career to a monomania. Juan criticises the Devil for advocating for "love and beauty and the rest of [his] favourite boredoms" and equates "love and romance" with "prudery and fastidiousness"; he also prophesises before the Devil that the romantic delights of hell will fail to deceive men and women in materialising the birth of the supermen (pp. 149, 160).

Tanner, however, at last balances this sweeping devaluation of romanticism by affirming before the pessimistic Ann that he actually is enamoured of her and is also concerned about her beauty. Tanner's outlook on romance, however feebly it is expressed, is important since it is meant by Shaw to mature into the birth of a superman. On the other hand, the artist is a romantic man and always worships woman and seeks inspiration in her; thus, Octavius admits that only Ann can imbue him with inspiration indispensable for his composition. But it is the women who want from men "the worship of woman, of motherhood, of the family, of the hearth" (p. 148). So Ann tells Octavius that marriage must not be let to "disillusion" him and that his ideal of her "divinity" must remain impregnable and sanctified (p. 193). Tanner has early in the play drawn comparison between the "artist man" and the "mother woman" in their "treacherous and remorseless" struggle for success and the contrast between them where the "true artist" is a "half vivisector, half vampire" to the woman (pp. 61-62). Octavius' relationship with Ann is severely constrained because he is not an artist of this type and because, as Ann discloses before him, he is "very foolish about women" (p. 195). Ann selects Tanner because he has practical eloquence and "self-consciousness and self-understanding", which are the prerequisites of a man for a nubile woman and which can produce an intellectual superman (pp. 150, 165). Ann rejects Octavius, who "sees nothing in nature but romantic scenery for love duets", because the "poetic temperament", standing for all artistic temperaments, is only "an old maid's temperament" (p. 204). Ann's is not an all-out rejection of the artist, yet her rejection of the artist in favour of the practical man, the philosopher, is important because she is to give birth to an intellectual superman, though she does not know it or is not yet ready to voice her support for it. Her choice depends on Shaw's Life Force doctrine, and thus she is guided by the instinct of the queen bee.

Even with his Life Force doctrine and the drone-bee chase, Shaw wanted to show a "freer and more varied comradeship between men and women, romantic and otherwise" and "more complex, intellectually challenging relationships"; furthermore, as a late Victorian dramatist, he had a question in mind: "in a more egalitarian, more honest, less restrictive society, what might marriage look like?" (Christian, 2020, p. 8). Shaw's concern about marriage is more important than his Life Force doctrine, for which he has imported the idea of the drone-bee relation; yet he is entangled in showing how this female pursuit of male works out, not in how marriage takes place or is consummated or how it impacts married people's lives. In *Man and Superman* marriage in its legal sense is not the only culmination of the relationship between a man and a woman. The characters are cogently different in their views about marriage and this difference in their views is interrelated with the difference in their attitudes towards the morality and purpose of marriage. Octavius does not credit Tanner's and Ann's caution that marriage will desiccate him of the artist's zeal and inspiration because of marriage's hard-hitting realities; so he persists in his love for Ann. Hector Malone believes that marriage ennobles a man and in reality, he induces his father to shirk his vindictive attitude towards the English aristocracy as he manifests his manhood and resolves to earn for his family with his own labour. Dona Ana in hell protests that "marriage peoples the world and debauchery does not", and she is vindicated by her marriage with Ottavio, which produces no fewer than twelve children (p. 158). Don Juan strongly differs from Dona Ana, whose "transports of virtuous indignation" caused mortal troubles to one of his love adventures when he was a "dastardly seducer"; thus he considers marriage to be "the most licentious of human institutions", a belief which emphasises that Life Force does not rely solely on marriage for sexual relationship and reproduction of supermen (pp. 156, 164).

Since female pursuit of the male is important, whether one wants a superman or not, marriage is not indispensable to Shaw, and thus his male protagonists have a liberal attitude towards marriage. Jack Tanner's outlook on marriage and morality almost completely corresponds to Don Juan's, but Tanner is baffled in the practical life where he attempts to apply it. Juan presents women's insistence on "honourable" conditions for sex, which include marital property settlements, financial support, lifelong companionship, and most importantly perpetual monogamy; these conditions which he declares to be "exorbitant and inhuman" are entirely irrelevant to his plain desire to receive and give sexual gratification (p. 162). Tanner's idea that "not being legally married matters not" is practically disqualified by Violet to whom it was intended as a buttress (p. 82). Tanner's appreciation of the supposed extra-marital love of Hector, "mere marriage laws are not morality", is shattered by Hector's revelation that he is the husband of Violet (p. 188). However, Tanner's ideological support for the "weeping Magdalen and an innocent child branded with her shame" significantly reflects Juan's philosophical prophecy that a day will come when morality will not be a detrimental obstacle to the procreative relationship between men and women (p. 68).

Thus, Bernard Shaw advances a proposal of eugenics discussed in the play's prefatory epistle and in Tanner's "Handbook", where sexual relationship is considered impersonal and marriage not indispensable. According to A. Silver, Shaw thought that in "his self-appointed role as artist-philosopher and master of reality" he himself made a "blunder" in getting married and was facing at that time his wife Charlotte's arguments for "avoiding coitus","the most telling" of which was her "fear of pregnancy"; thus, the playwright, "socially conscious even in his sexual fantasies, or allowing himself to indulge them only on condition that he will not find them too obviously pleasurable, envisions [in the play] ways of solving his present matrimonial difficulties" (1982, pp. 155-58). Likewise, Tanner who has considered marriage an "apostasy", "violation of my manhood", and a "shameful surrender", ultimately submits to the Life Force embodied in Ann and so renounces "the romantic possibilities of an unknown future for the cares of a household and a family" (Shaw, 1946, pp. 203, 208).

If Shaw's female characters like Ann Whitefield and Dona Ana as well as Violet Robinson are practical-minded, intelligent, and assertive, his male characters like Jack Tanner and Don Juan have some blemishes. But most importantly, all these male and female characters are equally strong-willed, resolute, and intelligent. And thus, if any Life Force is working behind them to produce supermen, both men and women possess almost an equal share. "Femaleness is subordinate to those integral characteristics of Superman, which are in turn subordinate to the universal will of the Life Force" (Zabrouski & Kirschmann, 2006). The drone is ultimately the mate and the victim of the bee as a result of the Life Force.

The consequences of such marriages are, however, delineated as ambivalent. Juan's contention that "sensible people make the best of one another" in wedlock reflects Tanner's anxiety, who believes that a "woman's business [is] to get married as soon as possible and a man's to keep unmarried as long as he can", and who prefers to be a slave of his wife rather than be a brutal husband with "a poker and a pair of hobnailed boots" (pp. 91, 157). But Tanner finally seems to be assured by Ann that his happiness in marriage will compensate for his "freedom and honour and self" despite her fear of some personal unhappiness and possible death (p. 205). However, Tanner's failure to discern their happiness in their final decision of marriage is inundated under the "Universal laughter", which prognosticates a happy and successful union between the hero and the heroine, and shows the dramatist's tact in using the drone-and-bee motif for comedic purpose as well as his sense of when and how to deviate from it (p. 209).

However, in his play subtitled *A Comedy and A Philosophy*, Shaw does not give the idea of this Life Force a truly philosophical look; he never forgets that this is a comedy which he is writing. All the comic effects of his play depend upon the different motivations, dialogues, and actions which proceed from his women's ceaseless pursuit of men, whether Life Force compels women to produce supermen or simply forces them to mate with their male "victims". Moreover, and interestingly enough, it is the Devil who first gives the label of "Life Force" to Juan's philosophy of man's higher purposes for which he is destined; and with ready wit, Juan admits that "the Life Force is stupid", though not "so stupid as the forces of Death and Degeneration" because "Life wins" somehow (p. 148). And it is only after this dream scene in Hell that Tanner first uses the term, and when he learns that he has been tracked out by Ann in Granada, he just exclaims: "The Life Force! I am lost" (p. 175). Moreover, in the prefatory Epistle Dedicatory, Shaw observes: "Philosophically, Don Juan … follows his own instincts", and whenever he "finds himself in mortal conflict with existing institutions", he "defends himself by fraud and farce as unscrupulously as a farmer defends his crops by the same means against vermin" (p. 10). Furthermore, Shaw himself calls Juan's customary pursuit of women a "tragi-comic love chase of the man by the woman" (p. 18). And with all these comedic illustrations of the doctrine of the Life Force, the playwright shows the relationship between man and woman to be one between the drone and the bee, where the male partner's fear of being annihilated in sexual union is only to augment the play's comical effects.

Conclusion

In *Man and Superman* G. B. Shaw has used the drone-and-bee motif successfully and produced comic effects; his male characters show their fear of sexual union to the end of the play whereas his female characters pursue them ceaselessly and finally become victorious, whether for their enlightened progeny or not. The female protagonists are depicted as demonstrating the power and purpose of the Life Force, of which they are the primary and active agents though all of them do not emphatically pertain to any such view. Shaw ultimately reconciles the vitality of women and men's conscious knowledge of this for a meaningful and reciprocal relationship that shows optimistic signs of culmination even in marriage, and for this the relationship is intellectualised and different questions of morality are introduced and discussed.

As a dramatist, Shaw has exploited the drone-and-bee motif to the end of the play in order to enhance its comic effects, but he has used the idea of a superman to deviate from the crudity of the drone-bee relation as well as to add another dimension to it. Thus, in his play *Man and Superman*, which he has also termed *A Comedy and A Philosophy*, Shaw is both philosophising about the relationship between man and woman and providing as much comedy as he can by using the drone-and-bee motif and modifying it for a higher purpose.

Conflict of interest

The author declares no conflict of interest.

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ORIGINAL ARTICLE ARTS & HUMANITIES

THE "MARBLE-HEARTED FIEND": MATERIAL, PSYCHOLOGICAL, AND SPIRITUAL ASPECTS OF PARENT-CHILD RELATIONSHIP IN KING LEAR

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Abstract

The parent-child relationship is one of the most important subject matters in Shakespeare's *The Tragedy of King Lear* in the sense that from it naturally spring the major themes of the play. Themes like regeneration of wisdom, distribution and effect of power and pelf, human and divine justice, and man's relationship with man and nature, are all presented on a universal scale, spatial and temporal, passing from the palace to the hovel, from the court to the heath, and from moments of folly to moments of enlightenment through moments of purgatorial sufferings. This universal scale can be regarded as connected to the political contexts of Britain, modeled on the prototypical and primary unit of a family. And since family, which involves principally the begetter and the begotten that also has the potential of begetting, is the primary and fundamental unit of the whole universe from both human and animal perspectives of life, this paper seeks to investigate how the familial background of the parent-child relationship in *King Lear* is portrayed against the backdrop of the kingdom and the universe. In order to do so, these three units – family, kingdom, and in natural and metaphysical senses the universe – are considered to be deeply interconnected with human relationships, corresponding consecutively to its psychological, material, and spiritual aspects. Shakespeare has illuminated the tragic truths about the relationship between the parents and their children by showing a profound interaction between the family, kingdom, and the universe with respect to their corresponding psychological, material, and spiritual aspects.

Keywords: Drama, parents, children, material concerns, psyche, spirituality

Introduction

King Lear is one of the four great tragedies of W. Shakespeare (Bradley, 1992; Muir, 1963), where the playwright has delineated multifarious aspects of the relationship between the parents and their children. There are numerous studies on Shakespeare's *King Lear*; many of them are from the perspectives of Lear's psychology, his relationship with his daughters, the question of material power, as well as from moral standpoints while some are from supernatural perspectives too.

To speak of material concerns like power first, there have been various studies conducted about the role of the kingdom in *King Lear*; for example, the question of hereditary monarchical succession (Hadfield, 2003); the psychology of power (McLaughlin, 1978); political contexts of Britain (Draper, 1937); political wisdom (Jaffa, 1957); politics and church (Greenblatt, 1985); and the role of Lear's desire in the transference of power (Stern, 1990). From psychological perspectives, there are several critical works; some explore Lear's psychology and death (Snyder, 1982; Hess, 1987); psychology of motives and particular forms of enactment (Chaplin, 1969); and Cordelia's moral psychology (Holiday, 2018). There have been many studies on Lear and his daughters including those by A. C. Bradley (1992), J. Kott (1965), L. C. Knights (1960), and M. Mack (1993). Some recent studies explore the nature of

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sibling relationships and parent-child relationships viewed from the perspectives of stage performance (Young, 2009; Davies, 2017; Schwarz, 2011), as well as mystical symbolism and inner drama (Lings, 2006).

Some critics have studied in *King Lear* the nature of justice and justice of nature (Heilman, 1963; Moseley, 1988; Lowenthal, 1997; Craig, 2001; Kahn, 2000). The Play has been approached from the perspective of sins and divinity, as well as patriarchy and contemporary political context (Linley, 2015). *King Lear* has been discussed from theological standpoints, for example, as a Christian play (Chambers, 1940; Knight, 1936; Wilson, 1929), as well as from non-theological viewpoints, without trying to fit it into Christianity (Empson, 1952; Sewell, 1951; James, 1951). *King Lear* is also considered a pagan play (Elton, 1980), yet "neither wholly pagan nor wholly Christian" (Halio, 2005). Nature has been studied in the play and found to be both benignant and malignant, but "strongly contrasted and mutually exclusive" (Danby, 1948, p. 19), and the principles of hierarchy and correspondence in the great chain of being is also explored (Tillyard, 1952), while duality of "the human condition and its paradoxical mixture of nature and convention" is also examined (Cantor 2008, p. 248).

Though *King Lear* has been discussed from all these various perspectives as there are different important themes, one important point of focus can be to see the nature of the relationship between the parents and the children from a much wider angle. Taking into consideration the family, the kingdom, and the universe can provide this angle since these are the three important units that Shakespeare uses to reveal the parental and filial relationship, which has three related dimensions – the material, the psychological, and the spiritual.

In *King Lear,* the principal focus is on Lear's family and mostly on how he plans to redesign his relationship with his three daughters, as it constitutes the main plot of the tragedy. However, by exploiting a related subplot, which enhances the subtlety of the parent-child relationship with illuminating parallelisms and cogent contrasts, Shakespeare develops this subject matter of the parent-child relationship on a tripartite scale of family, kingdom, and universe through an in-depth representation of the material, psychological, and spiritual aspects of human relationship. *King Lear* as a play has a wide, universal appeal, which, for good reasons, appears to emanate from the causes, as well as the consequences, of the destruction of the familial harmony between the parents and the children and also its subsequent reconstruction. Since family is the basic unit of a society in any country, all the social and political dimensions of a human's life can be regarded as affecting the unit of a family and also as being affected by it. Since the play itself begins with and rotates on the questions of the political powers of the kingdom, the political context of the play can be considered as related to the material aspect of human life. The play also involves the issue of natural justice, considered as both universal, i.e., widely applicable, and immanent, i.e., widely evident in nature, if nature is regarded as both the physical universe, implying what is natural, and the metaphysical universe, implying the supernatural and the spiritual.

The play thus does not remain limited to a family environment only; instead, it expands the family context of parental and filial bonds and affections to far wider contexts, into the kingdom and the universe. On the one hand, there is the material aspect of power, which starts within the family but embroils the whole kingdom; and on the other hand, there is the spiritual aspect of ethics, which relates to the question of justice, i.e., the moral concept of justice and punishment. Moreover, there is the psychological aspect of human relationship that primarily pertains to the family members. The psychological aspect of this familial relationship involves emotions like love but extends to reason and folly. Therefore, this paper investigates the relationship between parents and children in *King Lear* from the material, psychological, and spiritual perspectives which traverse the grounds of the family, the kingdom, and the physical and metaphysical universe. These materials, psychological and spiritual aspects of human relationships are encapsulated in Shakespeare's phrase, the "marble-hearted fiend", which Lear uses to describe his daughter Goneril once she refuses to obey his conditions (1.4.214); through this phrase, Lear emphasizes the idea that due to vested material interests, the psyche of a human being desiccates into something like mere matter as well as into something utterly immoral, though supernatural.

Discussion

Two family units are introduced in *King Lear* both of which primarily pertain to father and children; and though mother figures are mentioned casually, they do not play an important role in impacting the father-child relationship. The families of Lear and Gloucester run parallel in this family drama of acute psychological and physical interaction by pointing out both analogies and contrasts. However, there is a metaphysical and universal aspect of this familial relationship, which is not only ominous but also foreordained. According to A. C. Bradley, the repetition of the parent-child relationship in the subplot, "startles and terrifies by suggesting that the folly of Lear and the ingratitude of his daughters are no accidents or merely individual aberrations, but that in that dark cold world, some fateful malignant influence is abroad, turning the hearts of the fathers against their children and of the children against their fathers" (1992, p. 224).

Lear has three daughters of whom two inflict injuries on him while the third endeavors to alleviate them, and Gloucester has two sons, one of whom toys with his life while the other tries to safeguard it against suicidal despair. There is a strong psychological dimension in the characters of both Lear and Gloucester, who are blind to parental love and consequently dissociate emotion and intellect in matters relating to their children. However, learning to see rightly, both the fathers can successfully reintegrate their emotions and intellect after almost parallel courses of rectifying sufferings, which shows that, despite marked contrasts, there are remarkable analogies between their respective causes of misjudgments, their sufferings, and recuperation as well as their enlightenment.

The Material Aspect: Everything Royal

King Lear is not a play where the king will carve out the kingdom after he hears from his daughters how much they love him and give them the parts according to their love. In this play, the king has already measured his daughters' love and carved out the kingdom accordingly. What he intends to do is to find his assessment reflected in his daughters' protestation of love so that he can distribute the parts accordingly. And this he wants to do to satisfy his royal ego, and that too before the royal court.

King Lear at the very beginning of the play is presented in his royal court and in a royal manner, quite naturally, but when he begins by saying, "we shall express our darker purpose" though "we have divided / In three our kingdom" (1.1.31-33), some premonition is sparked in the audience's mind as to the psychological condition of the king's mind, and also as to how his psyche with the "darker" intention will deal with the material powers of a king. What is presented to the audience is a king with a formidable psyche. Therefore, it is not unusual that Lear does not refer to any gods at the beginning, but he does so only when his most beloved daughter Cordelia would decline to participate in Lear's moral game of justice, the universally famous trial of love of the three daughters; and infuriated with Cordelia's stubbornness, when Lear refers to gods, he first refers not to any god-like Apollo or Jupiter or Juno, but to the goddess of the lower world, the patroness of witchcraft:

> For by the sacred radiance of the sun,
> The mysteries of Hecate and the night,
> By all the operation of the orbs
> From whom we do exist and cease to be,
> Here I disclaim all my paternal care,
> Propinquity and property of blood,
> And as a stranger to my heart and me
> Hold thee from this forever. (1.1.103-10)

Lear mentions the metaphysical universe, the supernatural world, so strongly because his psyche has become turbulent, because he feels disconnected from his dearest family member, and because his sense of power as a king to disinherit a child becomes overwhelming.

Lear's psychological condition is presented as extremely flawed at the beginning of the play so he lets his material power and concerns overrule his moral and spiritual thoughts. Carving the kingdom proves to be breaking the family, so much so that the metaphysical universe he connects with is only the nefarious one, suitable to his mental state. Though none of his daughters mentions the gods or refers to the supernatural world in the first scene, Lear swears by Apollo and Jupiter when Kent is being scolded and banished because he is trying to bring Lear to his senses (1.1.154; 1.1.172). In the same breath Lear disowns Cordelia, he says before her and the full court that what is more intimately covetable than his "sometime daughter" is the cannibalistic peoples who feed upon parents and children (1.1.110-14). How infuriated Lear is at the reply of Cordelia is visible in what he says to Kent: "Come not between the dragon and his wrath" (1.1.116), a reference to the natural world, selected because it is extremely dangerous. Lear is in fact indicating the disintegration of the family bond, both the paternal and the filial connections, but he is not relying on the moral dictates of the spiritual world, the supernatural universe, nor on the natural world that would show normal psychology.

To Lear, love is not all; power too is important; thus, family or daughters are not his only concern or the first priority over the kingdom. The material concern seems too important and plays a pivotal part in creating the tragedy. Lear says that his "fast intent" (1.1. 33) is to "shake all cares and business from our age, / Conferring them on younger strength while we / Unburdened crawl toward death" (1.1. 34-36); but he refers to leaving power only parenthetically and tangentially as he wants to be relieved of the work and stress, but not the kingship, even if titular only: "(Since now we will divest us both of rule, / Interest of territory, cares of state)" (1.1.44-45). And only after he disowns Cordelia, he does make plain to his other daughters his intention, possibly his "darker purpose", his desire for "reservation of a hundred knights / By you to be sustained" (1.1.127-28), "only we shall retain / The name and all th' addition to a king: the sway, / Revenue, execution of the rest" divested to the two sons-in-law (1.1.129-131). Lear's ego is hurt, and his psyche is disturbed, but more than anything it is his royal pride that takes the brunt of the failure of the love trial; thus, before the full court he speaks of "strained pride" and "our displeasure" and says to Cordelia: "Better thou / Hadst not been born than not t' have pleased me better" (1.1.163; 1.1.193; 1.1.228-29). Lear's psyche is molded by his love for material power, not less than by his love for the daughters. Kent's clarification of it ("To plainness honour's bound, / When majesty falls to folly") will not make Lear see that his error of judgment lies in connecting love with power (1.1.142-43).

What most apparently and widely seems to lie in the heart of the tragic parent-child relationship in *King Lear* is the material aspect of Lear's relationship with his daughters, and it undoubtedly is seen linked with the question of power, which, however, is connected neither with the family, nor with the natural or metaphysical universe, but with the kingdom itself. "The transference of Lear's kingdom occasions the very tragedy it is designed to prevent", argues J. Stern (1990). However, more than the court, or the supernatural world, it is his own psyche that is more important to King Lear at the beginning of the play unlike the end. Tragedy of Lear ensues because he fails to strike any balance between family, kingdom and universe, and instead gives all-out importance to his own psyche, tainted with royal pride. When family and court fade into nonentity, the metaphysical universe also loses its proper significance, which however would gain strength later when Lear's agony will multiply soon through his two daughters' desire for material powers and manipulation of the kingdom's affairs. Lear's psychological condition determines his character and action as it is affected by his material concerns; moral considerations are immaterial at the beginning of the play.

The Psychological Aspect: Love, Reason, and Words

Apart from power, which relates to the material aspect of human relationships, the most important causes of the destruction of the harmony between the parents and the children in *King Lear* are psychological. Love, the folly of dissociating emotion and intellect, hypocrisy, and rashness are interlinked and one evolves out of another. Love, the root of familial harmony, paradoxically becomes the primary cause of its disintegration. There is an overbalance of love on the side of the fathers. Lear's love for his children is initially discriminatory while Gloucester's is not. Lear says about Cordelia, "I loved her most" (1.1.117), whereas Gloucester says to Kent, before conspiracies begin, that Edgar "yet is no dearer in my account" (1.1.16) than Edmond and later says that "I loved him, friend, No father his son dearer" (3.4.152-53). Love, whether overabundant or not, tends to be discriminatory, and this in Lear's case is the subconscious cause that prompts Lear to attempt unreasonably to weigh his daughters' love with the oratory of words, "merit" being practically unsought for even though it is mentioned (1.1.48).

Lear does his majestic and love-blinded folly by integrating love and power which once connected have the potential to exert explosive and corrupt power on the progeny whose love for parents is deficient. Power, once gained, brings out the power-crazy nature of Goneril: "If our father carry authority with such disposition this last surrender of his will but offend us as he bears" (1.2.294-96). The fear of losing power newly inherited through a flawed distribution overpowers Regan's and Goneril's filial love and impels them to disrespect and maltreat their father. Goneril, after insulting Lear, sardonically observes,

How have I offended?
All's not offence that indiscretion finds,
And dotage terms so. (2.4.288-90)

Thrusting out the father in the raging storm, Regan shuts the door because the king is "attended with a desperate train" of loyal knights who may "incense" him to regain his power (2.4.298-99). Lear has already diagnosed the cause of this familial discord and now he determines to change the scenario by assuming authority once again: "I'll resume the shape which thou dost think / I have cast off forever" (1.4.263-64). Love and power are conflated by

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Gloucester too, and it becomes the root of his parental discomfiture. Edgar is poisoned in Gloucester's ears because Edmond cannot obey the law of inheritance, the "plague of custom" (1.2.3), which precludes the illegitimate from rightful inheritance. Having Edgar disinherited, Edmond is prompt to hand his father over to the ruthless Cornwall to be falsely accused of treason so that he himself can be the Earl of Gloucester: "The younger rises when the old doth fall" (3.4.22). Shakespeare clearly shows how materialism can seriously undermine the psychological foundations of familial bonds, especially when it is filial and parental. Greed for material power, whether the kingdom is in full or parts of it, destroys the roots of the families in *King Lear*.

Shakespeare shows that the materialism of treacherous children can reveal their psychological depravity which not only can desiccate filial love but also can, as a consequence, jeopardize the very life of the parents because materialism shatters love, which is universally regarded as the core of a family. To gain power, these children with deceptive hearts exploit their parents' love; furthermore, these children lacking proper and sufficient filial love and responsibility resort to hypocrisy because they know that love impairs the intellectual faculty of the parents. Pretentious and inane phraseology is the medium of hypocrisy that the two elder daughters of Lear adopt. Thus Goneril, the eldest, professes with a sonorous rhetoric that she loves Lear "As much as child e'er loved, or father found" (1.1.54). Ironically, her love for Lear is not "Beyond what can be valued, rich or rare" (1.1.52), and becomes a forfeit she has to pay for her love for power which desiccates her filial obligation. After stating that Goneril "names my very deed of love", Regan asserts, "Myself an enemy to all other joys / Which the most precious square of sense possesses" (1.1.66-69). Regan's protestation too is extremely ironic since she later develops adulterous love for Edmond and neglects utterly the welfare of her father.

However depraved some children can be, not all the children in a family are unloving, power-crazy and immoral, Shakespeare shows; therefore, the loyal and caring children can easily identify pretentious expressions as reflective of the dark psyche of the ungrateful siblings. Thus, cogently contrasted to the two elder sisters' hypocritical protestations of filial love is Cordelia's simple and straightforward expression that "I shall never marry like my sisters to love my father all" (1.1.98). This exasperates Lear quite unreasonably even after she plainly explains:

> You have begot me, bred me, loved me. I
> Return those duties back as are right fit,
> Obey you, love you, and most honour you. (1.1.91-93)

Cordelia, who loves her father "According to my bond, no more nor less" (1.1.88), consciously lacks "that glib and oily art, / To speak and purpose not" (1.1.219-20), and is repudiated and banished by her father, whom she has to leave in the hostile hands of the "professed bosoms" of her sisters with an earnest appeal, "Love well our father" (1.1.265-66).

Because Lear conflates love and power, he is incapable of detecting hypocrisy, yet he puts all his faith in the protestation of love in ebullient phrases. He does not realize that such declamations cannot be expected to be sincere when he is losing his authority by renouncing his power. Thus blinded, he cannot reconcile himself to that bare and jejune fact and brushes aside Kent's explanation that they are not "empty-hearted whose low sounds / Reverb no hollowness" (1.1.146-47). While sonorous declamation is the strategy of hypocritical deception of the two of Lear's daughters, Gloucester's younger son Edmond's weapon of hypocrisy is an evil plot. Camouflaging Edgar's letter, Edmond deceives Gloucester whom he knows to be a "credulous father" (1.3.151), and who, consequently, allies himself with one son to punish the other whom he now believes to be parricidal in intention.

What Shakespeare presents as the psychological cause of parental failures, when it concerns the question of material power, is the intellectual folly of the fathers, which is the reason why they fall into such vicious pitfalls of the hypocritical children. A certain amount of impetuosity taints the judgments of both Lear and Gloucester. Goneril's observation that "The best and soundest of his time hath been but rash" may not be credible (1.1.286), but the inadvertence with which Lear disinherits Cordelia, banishes Kent and parts with the King of France is not unmistakable. This inadvertence is a natural outcome when the parental expectation of love is frustrated. Though Gloucester understands that "The king falls from bias of nature, there's father against child", he too readily gives credence to Edmond's words, ascribing it also to heaven's foreboding, without peeping into the matter for himself: "bond cracked 'twixt son and father. This villain of mine comes under the prediction: there's son against father" (1.2.96-98). This impetuosity of the two fathers is generated also by a tragic deficiency of insight so that their love for several of their children seems to be based on a very fickle and unstable ground – the fear of material loss, the loss of power of kingship and earldom. This lack of insight is produced when both the fathers fail to integrate their brain engendered intellect and their heart-generated emotion. There is no lack of love in them but their unfortunate decisions are taken when they decide to judge their children's love absolutely intellectually.

Had the two fathers taken into practical consideration their children's love, they would not have been content with mere words of the children and with their own peculiar reliance on the intellectual analysis of the situations, and thus would not have forfeited the family and lost their material power, though for a temporary period. When Lear decided to consider intellectually Cordelia's plainness of protestation as a proof that her love is too scanty, and when Gloucester regarded Edmond's hypocritical account of Edgar's supposed intrigue against his father as proof of Edgar's lack of filial love, both Lear and Gloucester were emotionally aroused but in a wrong direction, the direction towards hate, and this misdirected emotionalism of theirs could not naturally produce any positive and accurate emotional and intellectual assessment of the situations.

The psychological balance and imbalance of emotion and intellect both prove to be immensely consequential, whether in destroying the family and the kingdom or in rebuilding them. This association or dissociation of emotion and intellect plays its part not only in the fathers' case but also in the children's attitudes towards their fathers. The evil group of children demonstrates the hereditary traits of dissociating emotion and intellect and instead relying mistakenly, and preponderantly, on intellect in matters of the emotion of love. What they lack is filial love, not physical love which they exhibit excessively when they dislocate themselves from parental authority, as is evident in the evil love trio – Goneril, Regan, and Edmond. Their relentless suppression of filial love by judging intellectually that their fathers are not worthy of receiving it impels them to ignore their hearts and cherish material power and physical pleasures instead. This also deters them from realizing how evilly they have maltreated and vanquished their fathers.

Lear and Gloucester have the potentiality, and they later prove it, of reconciling emotion of parental love and intellect, and this trait of theirs is manifest in Cordelia and Edgar who always esteem a harmonious association of filial love and intellectual faculty. So, Cordelia must express this quality, however discordant it may sound in the love-trial scene, and continue to love Lear and struggle wholeheartedly to restore him to intellectual sanity. This is most vividly shown in her stoic encounter with the news of the deplorable degradation of Lear's psyche:

> All you unpublished virtues of the earth,
> Spring with my tears; be aidant and remediate
> In the good man's distress. (4.3.16-18)

Finding Gloucester venomed and enraged, Edgar cannot but flee, yet he later nurtures his father in distress and saves him from despair. He teaches his father that there should be a balance between emotion and intellect and that sorrows on earth are ineluctable but men must endure them and be ready for all possible consequences: "Ripeness is all" (5.3.11), and thus Shakespeare points to the universal and spiritual aspect of filial and parental bonds.

The Spiritual: Natural, Unnatural, Supernatural

Shakespeare integrates the family and the kingdom as well as the psyche and power in *King Lear*, but does not limit the parent-child relationship in the contexts of a family or a kingdom only. Instead, as a dramatist he takes every opportunity to impart a moral lesson on a far stronger plain by connecting the family and the kingdom with the natural and supernatural worlds, the universal context of moral concerns. To invigorate the moral lesson of family connections between the parents and the children, Shakespeare has extended the ethical domain of the play to a universal context. Universality does not remain fixed in the notion of the widest possible acceptability, but it encompasses everything, and to do so the playwright has from the beginning of the play refers to the physical and metaphysical universe whenever there is such an occasion. Thus, what Shakespeare presents as natural is not only related to what morality dictates universally but also what nature itself exemplifies through numerous instances. What is natural for a man to do or to be like is what is found in natural environment.

This duality of what is natural is a powerful strategy with which Shakespeare has delineated the different dimensions of relationship between parents and children. Though family and kingdom are extended to natural universe, and the psychological and material aspects of filial and parental connections are mostly delineated, it is the children's side that is most strongly indicated, and in this, what is unnatural is emphasized more than what is natural, and it is so because this is what pertains to the tragedy. So, the unnatural means not only what is universally unacceptable from the ethical point of view, but also what goes against the common phenomena in the natural universe.

Thus, as filial love pales into insignificance and nullity before the domineering wrong-headed intellect, the evil group of children demonstrates what Lear calls "Monster ingratitude" (1.5.32). This ingratitude, Lear realizes, is most unkind when it is inflicted by one's own offspring:

> Ingratitude! Thou marble-hearted fiend,
> More hideous when thou show'st thee in a child
> Than the sea-monster. (1.4.214-16)

"Parents' disappointment at their children failing to perform a filial duty is forcefully expressed" by Lear (Daniel, 2019, p. 2). Lear experiences how a daughter can turn against his father, as Goneril does, and he laments: "How sharper than a serpent's tooth it is / To have a thankless child" (1.4.243-44). Even physical pains are nothing in comparison to such mental agony as Lear experiences when he is repudiated and remains unsheltered in the storm:

> This tempest in my mind
> Doth from my senses take all feeling else,
> Save what beats there: filial ingratitude. (3.4.12-14)

However, what is unnatural, in the sense that it is against the laws of human nature, does not remain limited to human nature only, but is extended to the physical universe, i.e., the natural environment. Thus, Shakespeare provides some instances which show that aberrations and deviations occur in nature too, even as part of nature, precisely speaking the animal world. Shakespeare presents such instances in such a way that these natural phenomena seem morally unacceptable, and thus they can be easily regarded as unnatural. Lear's analogy comes to reflect what the fool has already predicted before him: "The hedge-sparrow fed the cuckoo so long, / That it's had it head bit off by it young" (1.4.175-76). The filial ingratitude undergoes such evil changes that it becomes a real mortal threat. Still feeling the hurt from his own daughters and feeling in his psyche empathy for a madman, i. e., the disguised Edgar, Lear refers not only to cruelty and death but also to natural justice and nature itself through his use of the image of the pelican, as it was "proverbial for feeding its young with its own flesh and blood, and the young were proverbial for cruelty to their parents" (Halio, 2005, p. 187):

> Nothing could have subdued nature
> To such a lowness but his unkind daughters.
> Is it the fashion that discarded fathers
> Should have thus little mercy on their flesh?
> Judicious punishment: 'twas this flesh begot
> Those pelican daughters. (3.4.65-70)

In every such instance, which normally seems improbable though not unimaginable, the emphasis is on the relationship between parents and their children.

To show the importance of what is normal and thus natural, Shakespeare emphatically portrays what may prove to be abnormal and unnatural in family bond, and for this he exposes the depravity of the human children in greater details. Both Lear's and Gloucester's families are involved in this unnatural act, where some of their children go as far as seeking death of their fathers, in fact plotting to kill them in order to usurp the kingdom and enjoy material power. The greed for material gains blinds these children to such an extent that they forget the emotion of love, let alone filial duty, and indulge in unnatural acts. Goneril and Regan, after exposing their father to the storm because he "must needs taste his folly" (2.4.284), degenerate to such a level that they want him to be killed. Gloucester says to Kent, "His daughters seek his death" (3.4.147) and "I have o'erheard a plot of death upon him" (3.6.45). The haste with which Gloucester shifts Lear to safety gives ample credence to this intrigue. Edmond too wants his father murdered. Knowing that the punishment of treason may amount to death and seeing that Cornwall is inflamed to hear the report of treason, Edmond leaves his father, after falsely accusing him of treason, to the revengeful Duke who now plucks out his eyes. Because Gloucester rescued Lear, Regan wants that Gloucester be blinded completely as he wants to save the King from being blinded by his own daughters, whom he represents as having nonhuman attributes from the animal world:

> I would not see thy cruel nails

Pluck out his poor old eyes, nor thy fierce sister
In his anointed flesh stick boarish fangs. (3.7.55-57)

Regan even later declares a reward for Gloucester's death. This life-threatening attitude of the children towards their fathers points to the monstrosity or unnaturalness of their individual making.

Lack of filial love, recourse to hypocrisy, dissociation of heart and brain, and demonstration of life-threatening ingratitude are some serious psychological deformities of Goneril, Regan, and Edmond, and thus point to the unnaturalness of the human psyche in a familial context. Unnaturalness here means the state of being an exception to the law of nature, the law of harmonious parent-child relationship. Shakespeare presents "familial connections as natural; consequently, violations of love and loyalty within the family are called 'unnatural'" (Young, 2009, p. 70). Edmond, the illegitimate product of Gloucester's illicit relationship with Edmond's mother, is portrayed as unnatural as a consequence. Edmond's contemptuous observation that the position of the stars at the time of his parents' sexual intercourse should make him "rough and lecherous" is ironically true (1.2.114-15). Though Kent finds this issue of the illicit sex "so proper", Gloucester drily states that "the whoreson must be acknowledged" (1.1.14-20). Distracted by Edmond's venomous words, Gloucester, however, terms his legitimate son Edgar as "unnatural" and becomes anxious that "the bond [is] cracked 'twixt son and father" (1.2.95-96), and later decides to bequeath his property to Edmond, his "Loyal and natural boy" as he calls him (2.1.83). Illegitimacy, however, is not the cause why Lear calls Regan a "Degenerate bastard" (1.4.209), and calls Regan and Goneril "unnatural hags" (2.4.271). Lear's words to Regan, who after a provocative neglect of her father formally expresses her gladness at meeting him, demonstrate that the daughter's mother was, in fact, not an adulteress:

If thou shouldst not be glad,
I would divorce me from thy mother's tomb,
Sepulch'ring an adultress. (2.4. 122-24)

However, Lear cannot but question "his own wife's fidelity. Could such unnatural creatures be his natural daughters?" (Klevar, 1972).

Infuriated and embittered even in the love trial scene, Lear is completely unable to diagnose the cause of such unnaturalness of his two daughters who do not know the "offices of nature, bond of childhood" (2.4.171). When Lear later utters in despair: "Is there any cause in nature that make these hard hearts?" (3.6.34-35), he is still seeking to explain the destruction of the filial bond by attributing the cause to human nature, i.e., the natural universe, and also to the supernatural, metaphysical universe where it seems to him uncertainty rules. Emotionally devastated and materially deprived, Lear has already taken his parental suffering to the spiritual realm when he first expresses his uncertainty about whether the gods are responsible for this:

You see me here, you gods, a poor old man,
As full of grief as age, wretched in both;
If it be you that stirs these daughters' hearts
Against their father, fool me not so much
To bear it tamely. (2.4. 265-69)

However, Lear has already with a grief-stricken heart acknowledged the evil daughters as a fault in his own nature, his psycho-physical constitution, the unnaturalness in his own, and says to Regan:

thou art my flesh, my blood, my daughter,
Or rather a disease that's in my flesh,
Which I must needs call mine. (2.4.214-216)

Gloucester, on the other hand, attributes the reason for the filial ingratitude to the perversion in human nature when he refers to Edmond: "Our flesh and blood, my lord, is grown so vile, / That it doth hate what gets it" (3.4.129-30). However, the play's final reasoning about the unnaturalness in the human psyche comes from Kent when he, like Lear, ascribes this to the metaphysical universe, as in the Quarto version of the play:

The stars above us, govern our conditions,
Else one self mate and make could not beget
Such different issues. (4.2.31-33, p. 305)

Kent's belief, which ignores heredity, is one-sided whereas Lear sought to fathom the cause of the unnatural aspect of filial bond in both human nature as well as in the metaphysical realm. However, apart from Regan's and Goneril's unnatural acts, Lear's own unnatural dealing with Cordelia is to a considerable extent responsible for his own "unnatural and bemadding sorrow" (3.1.09, p. 297). On an unjustifiable and irrational ground, he earlier pronounced his judgment on Cordelia, "I disclaim all my paternal care, Propinquity and property of blood", and said to her, "Better thou hadst not been born than not to have pleased me better", and wrongly called her "a wretch whom nature is ashamed almost to acknowledge hers" (1.1.228-29). It is thus evident that nature, according to Lear, is both human nature and the metaphysical universe, the latter he refers to as female, and also as just and invested with psychic power and capable of spiritual dealing.

Shakespeare shows what is unnatural and what therefore must be undone. And thus, poetic justice must be ensured to assert the restoration of the natural order or the order in nature, that is the natural world of humans and the supernatural, metaphysical universe; consequently, family harmony must be established, and in order to do so, justice must be meted out. The unnatural children must be punished, since "a society without justice and law would be monstrous and, in that sense, unnatural", and this is what "the play seems to confirm" (Cantor, 2008).

Shakespeare represents Lear's family as not distinct from his kingdom; however, more than this, he shows the family as innately connected with the supernatural universe. Such a connection helps the playwright show the moral considerations within a family as closely related to the supernatural universe, which in fact helps him to show that the psychological affairs in the human family in reality reflect the moral dictates of the spiritual universe. Because the material concerns mold the psychic activities of a family member, whether royal or not, both what is material and what is psychological become ultimately connected with what is spiritual. Thus, Shakespeare links up mind, matter, and morality from the beginning of the play. And this is why showing the spiritual universe and connecting it with the family and the kingdom is among the playwright's major concerns in *King Lear*.

To Lear the metaphysical universe becomes important since he can seek justice from it though, ironically, in the love trial scene he has shown his awareness of the supernatural world only after he receives his first shock in the play from his dearest young daughter. And though it is true that with "nature" he refers to human nature, the natural world and the supernatural world, he sometimes equates the supernatural world with the natural world itself, as he exclaims after Goneril refuses to shelter Lear along with his "hundred knights and squires" (1.4.196), his token of royal power: "Hear, Nature, hear, dear goddess, hear / Suspend thy purpose, if thou didst intend / To make this creature fruitful" (1.4.230-32). It is argued that Lear's address to the goddess is "closer to a personification of the orthodox Elizabethan conception of nature", which is Christian in spirit, since "God being the author of Nature, her voice is but his instrument" (Halio 2005, p.136). And it is also argued that Lear's curse on Goneril, "Into her womb convey sterility" (1.4.233), is very much like those of the Old Testament (Halio, p. 136). Lear wants that "the great gods" find out "their enemies now" (3.2.47-49), but considers himself less culpable: "I am a man / More sinned against than sinning" (3.2.57-58).

Lear suffers for his unnatural dealing with Cordelia and also for the unnatural treatment by Goneril and Regan, who in turn must suffer, which is more a punishment than suffering. This is the intricate pattern of heavenly justice Shakespeare presents where human beings, in this case, the fathers and the children, are employed as agents. This is what Albany predicted, and later he defines Goneril's and Regan's deaths as the "judgement of the heavens, that makes us tremble" (5.3.205), and in the Quarto version of the play Albany says:

> If that the heavens do not their visible spirits
> Send quickly down to tame these vilde offences,
> It will come.
> Humanity must perforce prey on itself
> Like monsters of the deep. (4.2.15-19, p. 302)

Through Albany, Shakespeare has expressed the universal idea of heavenly justice, where the supernatural intervention in human affairs is inevitable, even though it may occasionally be delayed, in which case there is the possibility of human transgression, which Shakespeare links to the animal world, suggesting that humans, unlike the animals, are supposed to be just in recompense, not transgressive in retribution, even when necessity so demands since humans have the faculty of reason, the token of the human psyche. G. W. Knight observes, "This question of human justice is, indeed, part of the wider question: that of universal justice" (1949, p.193).

Lear links universal justice to the metaphysical world, as he suspects that the gods are stirring "these daughters' hearts / Against their father" (2.4.267-68). However, he also seeks natural justice through divine intervention and invokes heavenly retribution on his evil daughter Goneril, which should be in the form of something unnatural: "Create her child of spleen, that it may live / And be a thwart disnatured torment to her" (1.4.230-238). Lear's execration of Goneril, "Th' untented woundings of a father's curse / Pierce every sense about thee" (1.4.255-56), is related to the psychological aspect of human existence. As Lear's curse comes true, Goneril forgets the bond of sisterhood for the sake of Edmond, whom Reagan desires too, and she poisons Regan to death before she herself commits suicide with a knife. "In the Edmond-Goneril-Regan group the philosophy of natural impulse and egotism has been revealed as self-consuming", observes L. C. Knights (1960, p. 107). But the supernatural intervention to meet out justice for the father and the daughters cannot be ignored. Lear's curse may have some effect on Goneril and Regan who persist vehemently in disregarding heart while malignantly insisting on their essentially flawed intellect and bodily pleasures; both of them die unredeemed.

Gloucester's prayer for divine intervention, "I shall see / The winged vengeance overtake such children" (3.7.64-65), applies not only to Regan and Goneril but also to his own son Edmond whose unnaturalness he can see, ironically, after being blinded. Edmond's hypocritical reflection, "the revenging gods / 'Gainst parricides did all the thunder bend" (2.1.44-45), proves ironically true for him. Mortal retribution is meted out to Edmond by Gloucester's legitimate and loyal son Edgar, who shows how justice is done through a human agency where the metaphysical intervention takes into consideration both what is righteous and what is wrong, as he also refers to his father before the dying Edmond: "The gods are just, and of our pleasant vices / Make instruments to plague us" (5.3.160-61). And as Edmond now learns to reconcile his emotion of filial love with his intellect, he realizes Edgar's meaning, "Th' hast spoken right; 'tis true" (5.3.163), and though he with Goneril signed the "note", their death warrant (5.3.28), he now wants to save the imprisoned king and his daughter from hanging "despite of mine own nature" (5.3.218).

Of Lear's three daughters, it is Goneril who barely speaks of gods, and it is because Shakespeare wants to show her as the most unnatural. Even Reagan mentions the metaphysical world as she utters, "O the blessed gods!" (2.4.161), when she fears a curse from Lear similar to that on Goneril, but that rare mention does not hide the fact that she too is unnatural. Cordelia, however, is seen as referring to the supernatural world of gods when she is nurturing her ill father: "O you kind gods, / Cure this great breach in his abused nature; / Th' untuned and jarring senses" (4.6.14-16), and she too, like Lear, speaks of human nature occasionally, as in this case of Lear's psychological condition. Edgar speaks of gods a few times, but always in reverence (4.1.12; 5.3.160), "the clearest gods, who make them honours / Of men's impossibilities" (4.5.73-74). However, to Edmond, the natural son of Gloucester, nature is a deity, to whom he asks for assistance in all his evil deeds: "Thou, Nature, art my goddess; to thy law / My services are bound" (1.2.1-2). Edmond's conception of the supernatural world, unlike his brother Edgar's, is evil: "Now gods, stand up for bastards!" (1.2.21-22).

The Psychological in the Ascendancy

In meting out justice, Shakespeare does not give metaphysical intervention the most important role. It is the human agents that the supernatural world acts through, and it is also the human psyche where both the vices and the virtues work. Thus, the psychological aspect of crime and punishment, sin and suffering, is no less important. As the two fathers have intellectualized their parental love and as that intellectualization has been unsound and essentially flawed, they must be rectified through a course of emotional suffering that they incur upon themselves and that is inflicted by their unnatural children. And such rectification of the fathers becomes complete as they feel once again the sincere and warm love of their loyal and faithful children, and as they realize their error of judgment, their tragic error.

Compared to Lear's realization, Gloucester's is simple. Once physically blinded, Gloucester begins to see mentally and correctly: "O, my follies! Then Edgar was abused. / Kind gods, forgive me that, and prosper him" (3.7.90-91). However, desiring ultimate physical destruction, death, to annihilate the mental agony of compunction, Gloucester becomes absorbed in despair and becomes critical of the metaphysical world: "As flies to wanton boys are we to th' gods; / They kill us for their sport" (4.1.36-37). Later, saved and nurtured by the disguised Edgar through a manipulated miracle, Gloucester learns to endure physical torment and mental anguish caused by filial hypocrisy and savagery:

> Henceforth I'll bear
> Affliction till it do cry out itself
> 'Enough, enough', and die. (4.5.75-77)

His integration of emotion and intellect is ultimately complete when he accepts Edgar's consolation as true, which is as usual a product of the integration of heart and brain, as he says,

> Men must endure
> Their going hence even as their coming hither:
> Ripeness is all. (5.3.9-11)

And only then can Edgar reveal his true identity to his reformed father, who can now see the psychic man in the moral universe.

Like Gloucester, Lear also shows self-immolating attitude because the mental agony is unbearable, and invokes the tempestuous nature to "let fall / Your horrible pleasure" against "a head / So old and white as this" (3.2.17-23). He too, however, tries to dispel despair, but finds the human and the metaphysical agents working together to wreck his psyche. Thus, he calls the elements of nature "servile ministers, / That will with two pernicious daughters join" (3.2.20-21), and takes shelter in a hovel assisted by a faithful retinue. Lear's mental agony has already deteriorated when he begins to realize his folly of intellectualization of love, i.e., intellectual measurement of love without integrating love and judgment:

> O most small fault,
> How ugly didst thou in Cordelia show!
> Which, like an engine, wrenched my frame of nature
> From the fixed place, drew from my heart all love,
> And added to the gall. O Lear, Lear, Lear!
> Beat at this gate that let thy folly in
> And thy dear judgement out. (1.4.221-227)

He realizes that his evil and hypocritical daughters "flattered" him "like a dog" (4.5.94-95) and regrets that he has given Cordelia's due rights to his "dog-hearted daughters", so "burning shame / Detains him from Cordelia" (4.2.43-45, p. 305-06). Lear says to her, "your sisters / Have, as I do remember, done me wrong. / You have some cause; they have not" (4.6.71-73); he also expresses his contrition:

> Thou art a soul in bliss, but I am bound
> Upon a wheel of fire, that mine own tears
> Do scald like molten lead. (4.6.43-45)

Lear expresses severe mental agony and extreme bodily pain, but above all, he alludes to his miscalculation about material power: "They told me I was everything; 'tis a lie, I am not ague-proof" (4.5.101).

The eldest of his daughters Lear has already termed the "marble-hearted fiend" (1.4.214), by which he emphasizes the fiendish nature of a human and stresses the moral, spiritual aspect of the human mind which is related to the supernatural universe. Through this phrase, Shakespeare shows the idea that since morality guides a human heart if a human loses morality, the mind loses its inherent goodness and the person turns, metaphorically speaking, into a marble, a meaningless matter, and more than that into something akin to an immoral, devilish supernatural being. However, Lear later admits before Cordelia, "I fear I am not in my perfect mind" (4.6.60), and moments before he will be last seen with Cordelia alive, he rejects her proposal of meeting the two evil daughters, and presents an all-encompassing vision with the truthful daughter, a vision where he merges the family with the kingdom as well as with the physical and the metaphysical universe:

> Come, let's away to prison.
> We two alone will sing like birds i' th' cage
> When thou dost ask me blessing, I'll kneel down
> And ask of thee forgiveness: so we'll live,
> And pray, and sing, and tell old tales, and laugh
> At gilded butterflies, and hear poor rogues
> Talk of court news, and we'll talk with them too –
> Who loses and who wins; who's in, who's out -
> And take upon 's the mystery of things,
> As if we were God's spies (5.3.10-17)

Here Lear shows the connection between the psychological, material, and spiritual aspects of human life. However, and more importantly, this shows that Lear now puts the family first, neither the kingdom nor the spiritual world. To him now the bond between father and daughter is the highest reason for existence, everything else being on the periphery – court, nature, and metaphysical mystery. However, the vision of a happy father-daughter relationship, regenerated at last though in captivity, is represented as being in harmony with the existence of a normal working court and colorful nature, complete only with the metaphysical universe, the supernatural and the mystical, both integrated into the prospect of a happy family.

Recognition of his own folly has already moved Lear, whom Cordelia calls "this child-changed father" (4.6.17), to seek atonement in prayer and pardon: "Pray you now, forget / And forgive. I am old and foolish" (4.6.81-82). No longer does he want to suffer from any revengeful feeling for his malignant daughters. Instead, he wants to end his life in a state of alienation from all kinds of material concerns, which earlier caused him to make all the psychological blunders and suffer consequently in mind more than in body. Since he has gained the knowledge and ability to renounce the material considerations, he happily accepts his fate of an enforced confinement along with Cordelia. And when he says, "Upon such sacrifices, my Cordelia, / The gods themselves throw incense" (5.3.20-21), he is reintegrating the conception of the family with that of the metaphysical universe. The family becomes more important to Lear than the kingdom, and becomes endorsed by the metaphysical world, so much so that he refuses to bow down to any plot of separation from the daughter: "Ere they shall make us weep. We'll see 'em starved first" (5.3.25).

When Lear's suspicion comes true, in his rage he kills the hangman of Cordelia but cannot save his daughter, as becomes apparent at the close of the tragedy. The death of his beloved daughter gives him another psychological blow, this time more devastating, as hopes of a reintegrated family fade altogether. A strong psyche Lear now shows to the world, whom he terms as pitiless and unsympathetic; however, no less important is it that, at such a point of existence, he finds even the metaphysical world as unmoved and unpitying:

> Howl, howl, howl, howl! O, you are men of stones.
> Had I your tongues and eyes, I'd use them so,
> That heaven's vault should crack. She's gone forever.
> I know when one is dead and when one lives.
> She's dead as earth. (5.3.231-35)

It is quite dramatic and ironic as well, that Lear can now demonstrate to the audience how important the human psyche is, for it is guided primarily by love and pity, the two emotions he lacked quite conspicuously at the start of the play. While emotions now have overtaken him, unlike those around him who urged him to show pity when he was disowning Cordelia in the love trial scene, what is no longer found to be responding to him in his direst emotional distress is the metaphysical universe, the pitying spiritual world that he often called to his aide after he began realizing his mistake. Now the psychological aspect of the human mind in the affairs of men, in the parent-child relationship, seems to him far more important than the spiritual world. The meaning of family lost, the metaphysical universe too now loses all its urgency, and thus Lear sees his beloved daughter Cordelia as merged with nature only ("dead as earth"), while he receives the news of his eldest daughters' deaths without any emotion at all, with a casual and meager response, "Ay, so I think", even after Kent's sorrowful portrayal of this tragic end, "All's cheerless, dark, and deadly" (5.3.264-66).

Remarkable it is that Lear learns to integrate reason with emotion, though to no avail, as is apparent in his frequent references to his ability to know whether one is dead or alive, even in his demand for a looking glass or a feather to examine if she is still breathing. The knowledge thereof or reason whatsoever cannot undo the lack of reason he showed at the beginning when he sadly lacked the emotion of love besides pity. Lear is now stressing the extent of his emotion again and again: Cordelia's life restored could "redeem all sorrows / That ever I have felt" (5.3.240-41). And as his psyche finds the loss too hard to bear, he curses the intrigue of the family and the court: "A plague upon you murderers, traitors all" (5.3.243). In his dying moments, Lear refers to the natural world, but no longer to the metaphysical universe: "Why should a dog, a horse, a rat have life, / And thou no breath at all?" (5.3.280-81), but thereby he only distinguishes his daughter's existence, and thus his concept of human existence, from the natural world too. To him now only the family, the connection between a father and his daughter, matters, and thus the psychological aspect of this relationship has all the cogency: "Thou'lt come no more, / Never, never, never, never, never" (5.3.281-82). And though Lear is seen as aware, however unconsciously, of his surroundings,

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i.e., the court and the kingdom, his last words before death reveal how he prioritizes, though at last, this family bond, this psychic connection with his daughter, more than anything else, whether the kingdom or the natural and supernatural worlds:

> Pray you, undo this button. Thank you, sir.
> Do you see this? Look on her! Look, her lips.
> Look there, look there. (5.3.283-85)

Lear's dying words show a stark contrast with how Lear, at the beginning of the tragedy, conceptualized his family, connecting it with the natural and the supernatural worlds, when his daughter Cordelia refused to cater to his royal ego, his folly of falsely tying reason with emotion on the ground of material power. The need for moral justice or natural justice is fulfilled at last, though through the tragic deaths of Lear and all his three daughters. Thus, the physical and metaphysical universe is upheld but is required no longer. What remains important is the psyche of a human, as it is only there that the fundamental connection with the family members lies.

Conclusion

The material concerns of Lear and his eldest daughters as well as Gloucester and his elder son have been most important in determining the relationship between the fathers and the children. Both the fathers realize their errors of judgment and their psychological mistakes, and both integrate their reason with emotion at last. The spiritual universe with its moral justice has always been behind the moral and immoral conduct of the family members, though not in any active role and working through human agents. What is conceived as moral is represented as natural, embodied in the physical universe, and ordained by the metaphysical universe.

Shakespeare begins *King Lear* with the questions of power in a kingdom, entailed by issues of love and reason in a family. And his tragedy ends where it began, i.e., in the family, which is decimated and no longer tied to material powers. Through his protagonist, Lear as a father, king, and moral agent of the metaphysical universe, as well as through the other father and all their children, the playwright upholds the supremacy of a family, the need for a family bond, the filial connection, and parental responsibility. Ultimately, it is the human psyche that is emphasized, not the material concern or the supernatural world. The family proves to be more important than the kingdom and the physical and metaphysical universe. The psychological aspect of family relationships outweighs all material concerns and spiritual needs though it is the latter two that determine a man's psychic journey from ignorance to understanding, from suffering to realization, and from pride to sorrow.

Conflict of interest

The author declares no conflict of interest.

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ORIGINAL ARTICLE

ARTS & HUMANITIES

ROBERT FROST'S "THE DEATH OF THE HIRED MAN": A MATERIAL FOR DEVELOPING STUDENTS' READING AND WRITING SKILLS

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Abstract
This study explores the effectiveness of a literary text as a material for developing students' reading and writing skills in an ESL/EFL classroom. It explains the reason why teachers should introduce a poem in a language class and also shows how they can extract benefits from it. Robert Frost's "The Death of the Hired Man" is the literary text explored in this study to demonstrate how different techniques of language teaching can be applied in a tertiary-level language class to develop the subskills of reading and writing. The techniques include guessing meaning from context, answering brief-answer questions, completing sentences, combining sentences, transforming sentences, changing narrative style, applying punctuation correctly, forming words, utilizing deviations, and writing paragraph, dialogue, and critical appreciation. Findings show that a poem – especially a well-selected one – can effectively be used as a material for developing students' language skills. Sample activities on two of the language skills – reading and writing – are formulated in this study from the aforesaid poem. The activities are set mainly on the basis of the subskills of reading and writing. Further studies on the same poem may focus on developing students' oral communication skills.

Keywords: ESL, EFL, poem, language class, reading skill, writing skill

Introduction

Literature can be an effective material for language teaching because it can be used as a perfect instrument to stimulate and speed up the teaching and learning process (Brumfit & Carter, 1986; Carter & McRae, 2014; Carter, 2007; Carter & Long, 1990; Phat, 2013). It is an authentic material for expanding students' language awareness (Collie & Slater, 1987; Lazar, 1993). It works as a wonderful source for developing students' linguistic competence. As an authentic material, it offers students a chance to process and interpret a new language, improve their vocabulary, deal with real-life situations, understand another culture, and develop their language skills.

Povey (1967) argues that literature provides not only evidence of extensive and subtle vocabulary usage but also complex and exact syntax which can be utilized in an ESL/EFL class. In fact, the use of literature as a technique for teaching both basic language skills (i.e., reading, writing, listening, and speaking) and language areas (i.e., vocabulary, grammar, and pronunciation) has become popular within the field of ESL/EFL learning and teaching (Hişmanoğlu, 2005). The study of literature particularly enhances the development of reading and writing skills. Reading develops sentence construction ability, enhances the knowledge of vocabulary, brings language fluency, and also helps students develop their own ideas. On the other hand, writing develops students' power of critical thinking and enables them to express their thoughts and ideas literally.

A distinct genre of literature, poetry can be considered a commendable way for developing the language skills of the learners of the tertiary level especially because it develops the skills of identifying and interpreting

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assumptions and implications (Tomlinson, 1986). Supporting this idea, Panavelil (2011) asserts, "[S]tudents who study poetry can simultaneously discover interesting ideas for creative writing" (p. 12). It motivates learners, develops their analytical abilities, and makes them aware of the sensitive expressions used by the poet. It is thought-provoking and capable of introducing the learners to various styles of language usage, especially with the deviations.

Considering the emphasis Tomlinson and Panavelil put on using poetry as a language teaching material, the poem "The Death of the Hired Man" (Frost, 1915; Frost, 1949) by Robert Frost (1874–1963) can be taken as a test case to find out whether it can be exploited for developing tertiary level learners' skills of reading and writing. This dramatic narrative poem was first published in 1914 in *North of Boston*, a collection of seventeen poems by the poet. The poem consists of 175 unrhymed lines in iambic pentameter. It is a dramatic poem that can be performed as a one-act play. Such dramatization of the poem may invite the attention of the learners and make the teaching-learning activities interactive and hence interesting. Besides, the everyday struggle of the characters, their conflicts, the idea of man's justice and woman's mercy, the relationship between husband and wife, between servant and master, etc. are such elements as are supposed to be familiar to all the language learners irrespective of their country, religion and culture. Considering different aspects of the poem, especially the ones that meet the demand of a language classroom, the present study aims at exploring the potential of the poem as a material for developing the reading and writing skills of tertiary-level ESL/EFL students.

Literature Review

Poetry helps students do well on high stake tests because it gives their minds an exhilarating workout (Mittal, 2016; Praveen, 2007; Stanley, 2004). As such, poetry inspires students to read more, imagine more, think more, discuss more, and write more. Most often it is seen that classroom tests and enjoyment are the two opposite things to combine. These opposite things may easily be addressed by using a poem for the purpose of language teaching. In this regard, the poem should be selected properly to ensure that it corresponds to the student's age and interest (Kırkgöz, 2008). Otherwise, it may prove useless. According to Mittal (2016), if teachers use a poem that is high in thought, full of mysticism and metaphysical elements, it will not serve the purpose. A poem that is free from the elements mentioned by Mittal is "The Death of the Hired Man." Written in a rather simple and lucid language, this poem can be a suitable material for the language class.

Poetry can be a powerful element for developing students' oral language abilities. It can lay a strong foundation for reading a new language and its use in writing classes can provide the learners with an effective and collaborative means of learning a language and delivering personal expressions through the language learned (Finch, 2003; Hadaway, Vardell & Young, 2002). As a part of this learning and expressing, as mentioned by Spiro (2004), advanced students can focus on pronunciation, spelling links, word-building skills, idioms, forming statements, questions, or negative forms. Expressing through writing helps students clarify their thoughts and remember what they have learned.

There is no doubt that reading and writing work simultaneously. Omojuwa (1997) found that reading and writing skills are actually closely related and could most often be regarded as one unified skill. Considering Omojuwa's views, this study specifically emphasizes on the development of students' reading and writing skills simultaneously.

A study conducted by Darmawati (2011) among 70 students of class XI shows that the use of poetry as an authentic material for language teaching was effective in improving the writing ability of the participants. For collecting necessary data, the researcher gave the participants the test of writing paragraphs twice: first as the pretest and afterward as the posttest. The study claims that the result of the posttest conducted among the experimental group was much better than that of the pretest.

Khan (2020) has attempted to facilitate the use of classic literary texts in ELT classrooms. She has explored Shakespeare's Sonnet 65 to illustrate some vital themes and crafted some activities out of the poem. In her study, the researcher has worked on activities related to pronunciation, vocabulary, prosody, deviant language, figurative language, poet's intention, and reader's expectations. Items of rhyme scheme, stress, and intonation are discussed in the prosody section. Some other items like alliteration, personification, assonance, consonance, and antithesis are discussed in the figurative language section.

The poem "Our Deepest Fear" by Marianne Williamson is used by Bidari (2021) as a teaching material for inspiring advanced students, aged 15-19, to use creative writing for enhancing their self-expression and also to give them the experience of mindful reading, listening, and writing. Besides the warm-up activity, she has kept four other activities: communicative activity, poetic activity, question-answer segment, and analysis of the poem. Communicative activity is included for building the background or setting the context. In the poetic activity, the task of filling in the gaps is given. The task of answering questions is given to allow the learners to express themselves. The tasks of bringing out the meaning of the poem and finding out its tone are included in the final activity.

Rahman and Sharif (2018) used one of Robert Frost's poems as a material for developing the reading and writing skills of students. Their work dropped an important grammatical item: the use of punctuation. Sufficient usage of punctuation is seen in dramatic narrative poems. Robert Frost's "The Death of the Hired Man" is no exception to this. Learners can learn various uses of punctuation from this poem.

Many analytical works on Robert Frost's poems are available as they are taught in literature classes worldwide. But works that exploit his poems in language classes are quite inadequate. The same is the case with his poem "The Death of the Hired Man." Analyses of this poem from different perspectives are available but its potentials as a material for developing students' language skills are yet unexplored. The present study is an attempt to work in that direction.

Methodology

This is a qualitative study where the textual analysis method is used. Data are collected from both primary and secondary sources. The text of the poem "The Death of the Hired Man" by Robert Frost serves as the primary source of this study. The secondary sources are different books, journals, and articles that are consulted to explore the tasks to be set for developing tertiary-level students' reading and writing skills.

Discussion

"The Death of the Hired Man" by Robert Frost is a rich source of materials for English language teaching. Different ESL/EFL tasks can be formulated by exploiting this poem. In this section, possible tasks for developing students' reading and writing skills are given.

Tasks for Developing Reading Skills

To improve students' reading skills, the following tasks can be formulated for the target students:

Brainstorming. Learners can start analyzing the poem with a brainstorming activity (Navaee & Asadi, 2015). According to Ghabanchia and Behrooznia (2014), brainstorming plays a significant role in developing learners' abilities in reading comprehension and critical thinking. The topic "home" can be selected for this purpose. The learners may be asked to think about the possible definition of "home". After a minute or two, the teacher can throw the question, "What is home?" Then he/she can elicit the answers and give necessary feedback. The answers provided by the learners will ensure their involvement with the topic. After that, the teacher may talk about the definitions of home given by the characters of the poem. The definitions are:
i. "Home is the place where, when you have to go there, / They have to take you in." (Lines 122-123)
ii. "…it [is] / Something you somehow haven't to deserve." (Lines 124-125)

Developing Vocabulary. According to Kolk (2015), a poem's purposeful selection of words encourages the learners to read it closely and carefully. She also asserts, "Word choice can also prompt rich vocabulary discussions since students can debate authors' word choices and explore multiple meanings and nuances." Students can also enrich their knowledge of vocabulary from the poem "The Death of the Hired Man" because there is ample usage of vocabulary in it. Some examples are (i) Musing (Line 1), (ii) Harbor (Line 15), (iii) Grudge (Line 52), (iv) Queer (Line 59), (v) Pique (Line 76), and (vi) Dislodge (Line 94).

Guessing Meaning from Context. Sometimes the meaning of some words can be decided by the context in which the words are used. Such a meaning of a particular word is termed as its contextual meaning. Richards and Schmidt (1985) define contextual meaning as "the meaning a linguistic item has in context, for example, the meaning a word has within a particular sentence, or a sentence has in a particular paragraph" (p. 128). The comprehension of the contextual meaning of a word used in a poem requires a student's deep involvement with the poem concerned. The students can be asked to guess the meaning of any word with the help of the context that the poem provides. They can be given multiple choices to identify the meaning. Examples are given below:

a. Beholden (Line 21)

i. Obligate	ii. To be hold	iii. Guilty

b. Coax (Line 28)

i. To Flatter	ii. To persuade	iii. To gratify

c. Nod off (Line 44)

i. Awake	ii. To fall asleep	iii. To shake

d. Jumble (Line 58)

i. To mix	ii. To unite	iii. To talk incoherently

e. Run on (Line 61)

i. Continue	ii. To run	iii. To talk constantly

Completing Sentences. Sentence fragments used in dialogues sometimes give insights into the mental construct of the characters, their changing thoughts, and their checked emotions. According to British Broadcasting Corporation (BBC, 2023), they are used to create a conversational effect, to put emphasis on a particular point, to create a dramatic effect, and to show surprise. Teachers can identify some incomplete sentences or sentence fragments used in the poem "The Death of the Hired Man" and can give the students the task of completing them according to their textual contexts. This task can introduce the students to all the dimensions the fragments can create. Examples of incomplete sentences used in the poem are given below:

i. "You remember………….." (Line 61)
ii. "Because he liked it…….." (Line 84)
iii. "We wouldn't mind him……" (Line 147)
iv. "you will be surprised at him…." (Line 159)
v. "I'd not be in hurry to say that…" (Line 162)

Answering Brief-answer Questions. Teachers can provide some brief questions and ask the students to answer the questions. This can assess their level of comprehending of the poem. Examples of such questions are given below:

i. What does the title of the poem suggest?
ii. How does Mary differ from her husband?
iii. What is Mary's attitude towards Silas?
iv. Why is Warren dissatisfied with Silas?
v. Why did Harold Wilson help Silas?

Tasks for Developing Writing Skills

Based on the subskills of writing, different activities can be set to improve learners' writing skills. Some of the writing activities set by exploring the poem "The Death of the Hired Man" are as follows:

Word Formation. Poetry is a great source of exploring new words and expressions. Different processes of word formation such as prefixation, suffixation, compounding, etc. are evidently found in poetry. Students can be asked to find the usages of prefixes, suffixes, and compounding for using them in sentences of their own. In the poem, sample words that use prefixes or suffixes are (i) dis-lodge (Line 94), (ii) un-load-ing (Line 95), (iii) be-hold-en (Line 21), and (iv) better-ing (Line 25). Examples of compounding can be found in the words (i) tip-toe (Line 3), (ii) pocket-money (Line 28), (iii) barn-door (Line 35), (iv) self-respect (Line 53), and (v) harp-like (Line 110).

Use of Mechanics and Punctuation. A writing subskill that is related to the manipulation of the script of the language is the correct use of mechanics and punctuation. There are evident usages of mechanics and punctuation in the poem "The Death of the Hired Man." This poem is full of commas, full stops, question marks, capitalization, single quotations, double quotations, colons, dashes, and hyphens. Teachers can ask the learners to find out the use of different punctuation marks from the text and ask them to form the rules of mechanics and punctuation from their findings. Sample findings are given below:

Comma

i. "I told him so last haying, didn't I?" (Line 13)

ii. "All right," I say, "I can't afford to pay / Any fixed wages, though I wish I could." (Lines 22-23)
iii. "Yes, I took care to keep well out of earshot." (Line 73)
iv. "Well, those days trouble Silas like a dream." (Line 74)

Colon

i. "Sh! Not so loud: he'll hear you," Mary said. / "I want him to: he'll have to soon or late." (Line 31-32)
ii. "Warren," she said, "he has come home to die: / You needn't be afraid he'll leave you this time." (Line 114-115)
iii. "But, Warren, please remember how it is: / He's come to help you ditch the meadow." (Line 163-164)

Hyphen

i. Pocket-money (Line 28)
ii. Barn-door (Line 35)
iii. Morning-glory (Line 110)
iv. Sharp-edged (Line 155)
v. Chair-back (Line 155)

Dash

i. "A miserable sight, and frightening, too— / You needn't smile—I didn't recognise him— / I wasn't looking for him—and he's changed." (Lines 36-38)
ii. "He jumbled everything. I stopped to look / Two or three times—he made me feel so queer— / To see if he was talking in his sleep. (Lines 58-60)
iii. He ran on Harold Wilson—you remember— / The boy you had in haying four years since. (Lines 61-62)
iv. "He thinks young Wilson a likely lad, though daft / On education—you know how they fought" (Lines 68-69)
v. "Why didn't he go there? His brother's rich, / A somebody—director in the bank." (Lines 133-134)
vi. "Warren returned—too soon, it seemed to her." (Line 172)

Capitalization

As poems use the most deviated form of common language, students can learn some interesting rules of capitalization from this poem. They can learn to capitalize the first letter of every line of the poem and the first word of a quoted sentence. Another striking thing is that the first word from the very first line of the poem is all capitalized to put emphasis on the word.

Developing Grammar. Different activities can be formed for developing students' knowledge of grammar – both within a sentence and beyond the sentence. For enhancing students' sentence-level grammar, the activity of transforming sentences is set while for developing their skill in the grammar beyond the sentence, the activity of combining multiple sentences is set. Changing the narrative style is set to address both these types of grammar.

Transforming Sentences. Teachers can give the learners the task of changing sentences or transforming sentences as directed in the parentheses that follow the sentences concerned. Examples of such sentences are given below:
i. "When she heard his step, / She ran on tip-toe down the darkened passage." (Lines 2-3) (Simple)
ii. "She took the market things from Warren's arms / And set them on the porch." (Lines 8-9) (Complex)
iii. "Who else will harbor him?" (Line 15) (Assertive)
iv. "He's finished school, and teaching in his college." (Line 63) (Simple)
v. "He never told us that." (Line 135) (Interrogative)

Combining Sentences. Teachers can use two or more sentences from the poem to be combined by the students. This activity will help the learners combine the idea that the relevant sentences possess and express it with precision. Sample sentences for combination are as follows:
i. "He's asleep beside the stove. / When I came up from Rowe's I found him here, / Huddled against the barn-door fast asleep." (Lines 33-35)
ii. "Its light poured softly in her lap. She saw / And spread her apron to it." (Lines 108-109)

iii. "He wouldn't let me put him on the lounge. / You must go in and see what you can do." (Lines 156-157)
iv. "He has a plan. You mustn't laugh at him." (Line 165)

Changing Narrative Style. As the poem "The Death of the Hired Man" is full of dialogues, teachers can select some speeches from the poem and give the learners the task of changing the narrative style. Excerpts from the poem will enable the learners to locate the speeches easily and to identify both the speaker and the listener or the person spoken to. Examples of some reported speeches along with the reporting clauses, placed at different parts of the expressions, taken from the poem are given below:

i. "Be kind," she said. (Line 7)
ii. "When was I ever anything but kind to him?
But I'll not have the fellow back," he said. (Lines 11-12)
iii. "All right,' I say, 'I can't afford to pay
Any fixed wages, though I wish I could." (Lines 22-23)
iv. "Sh! Not so loud: he'll hear you," Mary said.
"I want him to: he'll have to soon or late." (Lines 31-32)
v. "Warren," she said, "he has come home to die:
You needn't be afraid he'll leave you this time." (Lines 114-115)

Utilizing Deviations. When using poetry in the classroom, the deviant use of language found in it can be exploited for expanding student's language awareness and interpretative abilities (Lazar, 1993). The poem "The Death of the Hired Man" is full of syntactic deviations. So, exploitation of this poem can give the learners the scope to find out those deviations and convert them to regular prose. Some of the deviations are as follows:

i. "What good is he? Who else will harbour him / At his age for the little he can do?" (Lines 15-16)
ii. "Off he goes always when I need him most." (Line 18)
iii. "Nothing would do: he just kept nodding off." (Line 44)
iv. "Silas has better claim on us you think / Than on his brother? Thirteen little miles / As the road winds would bring him to his door." (Lines 129-131)
v. "Then there were three there, making a dim row, / The moon, the little silver cloud, and she." (Lines 170-171)

Some Other Tasks

Teachers can also exploit the poem to make the students perform some other common activities like writing paragraphs and dialogues selecting topics from the poem or activities like writing a critical appreciation of the poem and explaining its theme.

Teachers can give the task of writing paragraphs freely on any topic related to the poem. A possible title of the paragraph may be "Home." While writing the paragraph, students should use a topic sentence, necessary developers, and a terminator in the paragraph. They should also maintain cohesion and use necessary cohesive devices/discourse markers in it.

As a dramatic narrative, the poem is full of dialogues. Teachers can ask the learners to trace how dialogues are stated in a poem. They can also form different groups, give those groups different topics and ask them to write dialogues following the pattern used in the poem. In this case, the dialogue selected from the poem will serve as a model for the students and their task will be a guided one. However, the students should be asked to use necessary social English expressions towards both the beginning and the end of the dialogue concerned. Then teachers can explain the differences between written and spoken languages by analyzing the writing patterns of the written dialogues.

Teachers can also use this poem to develop students' concepts of academic and non-academic writing. They can assign the students to write on the theme of the poem because gradual and focused academic writing classes offered to graduate students in foreign language contexts will remedy the challenges faced during writing in the second/foreign language (Cennetkuşu, 2017). The learner can also be asked to write a critical appreciation of the poem. These things fall into the category of academic writing. On the other hand, when the learners are asked to write dialogues, it falls into non-academic writing.

Conclusion

The dramatic narrative style of Robert Frost's "The Death of the Hired Man," its subject matter, and its simple language expressed mainly through colloquial dialogues – all can work together to create interest among the learners and motivate them to learn. Tertiary-level learners may feel connected with the poem because of the universal appeal of its theme that develops through a conflict between a couple. The learners can easily relate their thought to the poem. It may improve their interpretative ability and can remove their monotony in language class.

Activities like guessing meaning from context, completing sentence fragments, and answering brief-answer questions can develop the reading skill of the learners while tasks like exploring the processes of word formation, correct application of punctuations, combining sentences, transforming sentences, changing narrative style, utilizing deviations and writing paragraph, dialogue and critical appreciation can develop their writing skill. For enhancing grammar, items from both within the sentence and beyond the sentence are incorporated in this study. Though most of the tasks can equally be formulated by using both prose and poetry, the task of utilizing deviations is possible to formulate only by exploiting poetry. Besides, tasks like changing the narrative style and tracing the application of punctuation marks are encouraged by the dramatic-narrative style of the poem. However, this study explores the possibility of using "The Death of the Hired Man" as a teaching material to develop students' reading and writing skills. Further studies are required to explore how this poem can be exploited for developing their listening and speaking skills.

Conflict of Interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

LIFE SCIENCE

PRIORITIZATION OF TREE SPECIES BASED ON GREEN LEAF NUTRIENT LEACHING: AN APPROACH FOR SUSTAINABLE AGROFORESTRY PRACTICES

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Abstract

Nutrients leaching from litter (leaves, bark, needles and twigs) have a major contribution to the supply and cycling of nutrients to crops. Among the litter parts, leaves are the main and quick source of organic matter to the soil whereas, green leaves return more nutrients than other forms of leaves. The return potentiality of K, P and N through leaching from green leaves of the major agroforest tree species: *Zizyphus jujuba*, *Melia azadirachta*, *Albizia saman*, *Dalbergia sissoo* and *Azadirachta indica* are presented on this study. Green leaves of the studied tree species were collected and then leached in water (deionized). Nutrient release through a leaching experiment was conducted for 192 hours. Percentage (%) of green leaf mass loss and Total Dissolved Solid with Electrical Conductivity of the collected leaching water showed a curvilinear relationship with time significantly ($p < 0.05$). NH_4, PO_4 and K concentration of the collected leaching water of the individual cropland agroforest tree species was significantly ($p < 0.05$) increased for 72 hours in the initial stage but at the later stage remained constant. Individual tree species showed the same nutrient release (K > NH_4 > PO_4) pattern. The highest concentration of 5121 ppm NH_4 and potassium (13357 ppm) was found for *Melia azadirachta* and the lowest concentration of 1424 ppm NH_4 and potassium (4410 ppm) was observed for *Albizia saman*. Results from the study highlighted that *M. azadirachta* was the best among the studied tree species in terms of nutrient return followed by *A. indica* and *D. sissoo*.

Keywords: Cropland agroforestry, green leaf leaching, nutrient return, prioritization, sustainability

Introduction

Bangladesh is a deltaic country, and its major economic activity depends on agriculture. Cropland agroforestry has become an important production system (Hasanuzzaman & Mahmood, 2015). Farmers plant trees for various purposes i.e., production of fruits, fuel wood, fodder, timber, and medicine (herbal) with ecological as well as environmental benefits (Ahmed, 2001; Ahmed et al., 2004). Around forty tree species (timber, fodder, fruit etc.) are used in different agroforestry practices in Bangladesh (Hasanuzzaman et al., 2014a). Whereas *Dalbergia sissoo*, *Zizyphus jujuba*, *Albizia saman*, *Azadirachta indica* and *Melia azadirachta* are common in Bangladesh (Aktar et al., 1992; Quddus, 2001; Hasanuzzaman et al., 2014a).

Trees and crops in a system have a positive contribution to nutrient availability for crops. Trees uptake nutrients from the sub-soil and a portion of these nutrients are returned to the topsoil of the cropland agroforests through microbial decomposition of litter (Hasanuzzaman & Mahmood, 2014b) and leaching from green leaves (Limon et al., 2018). The nutrients leaching from green leaves and leaf litter improve the fertility of the topsoil (Kimmins, 2004; Kumar et al., 2010; Kibriya et al., 2019) whereas, green leaves return more nutrients than other forms of leaves (Limon et al., 2018). Nutrients from the green leaves of the standing trees as well as from the cutdown branches (through different tending operations: thinning /pruning) can be released through precipitation. The nutrients released through the leaching mechanism for green leaves may have great implications in nutrient supplies to agroforestry practices (Hasanuzzaman & Mahmood, 2014b; Limon et al., 2018; Kibriya et al., 2019) without significant negative impact on the biodiversity.

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The nature and capacity of nutrient return through the leaching process vary with species, incubation time, the nutrient concentration of leaves and life form of individual trees etc. (Marschner, 1995; Jones, 1998; Mahmood & Saberi, 2007; Ali et al., 2013). Morphological characteristics, site suitability and people's demand are mostly considered for agroforest tree species selection in Bangladesh (Quddus, 2001; Mahmood et al., 2011; Sharmin et al., 2021). Whereas ecological and environmental benefits of the sustainability of agroforestry system are highly ignored. Therefore, this study was conducted to prioritize the commonly used cropland agroforest tree species based on the efficiency of nutrient return through leaching from green leaves. The outcome of this study can draw peoples' interest to consider as another criterion to select tree species in agroforestry practices.

Materials and Methods

Site description

The southwest region of Bangladesh is a fertile deltaic plain with a composition of calcareous - noncalcareous alluvium soils which is low and flat (BBS, 2004). Khulna, Jessore and Satkhira districts of the south-west part of Bangladesh were selected for this study which lies between 89°01'-89°36' E and 22°44'-23°14' N (Figure 1).

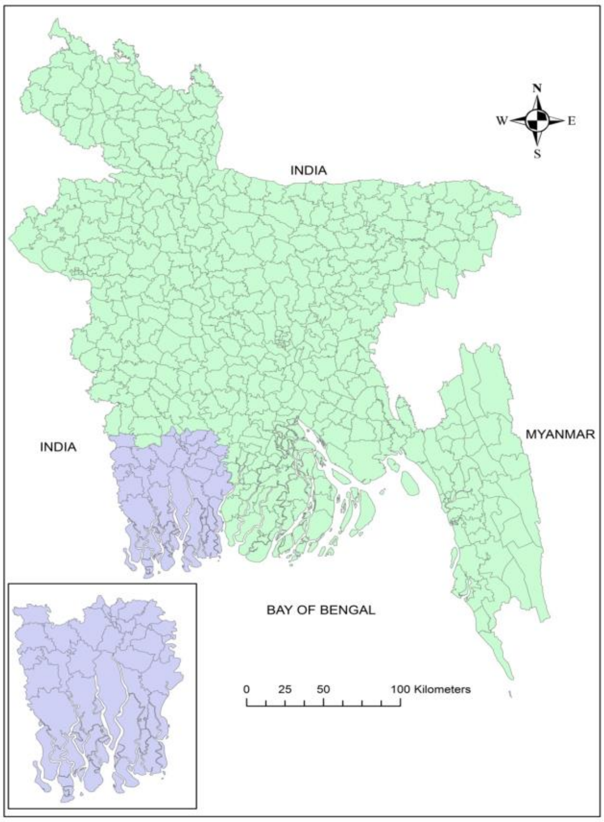

Figure 1. Location of the study area.

Three distinct seasons i.e., rainy, winter and summer prevail in this area having a tropical-subtropical monsoon climate. The average annual rainfall is about 1,800±268 mm. The mean annual temperature is 26 °C. During the years, January and May are the coldest and warmest months respectively (Kabir & Webb, 2008). The highest relative humidity (86%-88%) prevails during July-August whereas, whereas the lowest relative humidity (72%-74%) prevails during February-April in this area.

Green leaf Collection and experimental setup

Two kilograms of green (newly flushed) leaves were collected from the individual tree of *M. azadirachta*, *A. indica*, *Z. jujuba*, *A. saman* and *D. sissoo* from March to April from study sites. In this period, new leaves flash on the trees which contain a higher portion of nutrients (Lin & Wang, 2001; Wright & Westoby, 2003; Fonte & Schowalter, 2004). In addition, this is the driest period in Bangladesh and almost no rainfall occurs during that period. So, there is no chance of leaching from leaves on the existing trees. The collected green leaves were thoroughly mixed and air-dried for one week in natural conditions at room temperature (Figure 2) and then weighed to five gram as an individual sample.

Figure 2. Air drying of green leaves for leaching experiment.

At the same time, five leaves of a sample of each species were kept for four days in the oven at 80 °C (Hasanuzzaman & Mahmood, 2014c) and then the conversion weight ratio (air dry to oven dry) was calculated. The dust particles on the surface of the leaves were removed by soft brushing and rinsing them for a few seconds with deionized water (Turner et al., 1992; Kumar et al., 2010). Eighty-five leaves samples were put in each beaker of 500 ml. Then deionized water of 200 ml with a few drops of mercuric chloride solution ($HgCl_2$, 50 mg/L) was provided in every beaker for preventing fungal attack (Ibrahima et al., 2008). At last, the beakers were placed in a normal condition at room temperature (30 °C) for continuing the experiment for up to 192 hours.

Collection of samples and measurements

Five samples were collected at an interval of short duration (0.5, 1, 1.5, 2, 2.5, 3, 4, 8, 12 hours) in the initial stage and at the end it was longer (24, 48, 72, 96, 120, 144, 168, 192 hours) for each species (Kibriya et al., 2019). After the collection of leave samples, it was dried in an oven for 96 hours at 80 °C (Hasanuzzaman & Mahmood, 2014c). The mass loss calculation was performed by deducting the initial weight from the final (oven-dried) weight of the samples. The mass loss rate was calculated using the mass loss of the leaf with respective leaching time. TDS and EC of the collected water were measured at the time of sample collection by an Electrical Conductivity meter (Model: EC-470L, Istek, Inc., Korea). 100 ml of the collected leaching water of each species were stored for future analysis.

Nutrients addition in leaching water

NH_4, PO_4 and K concentrations were measured from the collected leaching water at different time intervals. NH_4 concentration was measured by following Weatherburm, (1967); PO_4 concentration was measured using a UV-Spectrophotometer (HITACHI, Model: U-2910, Japan) by following Timothy et al., (1984) whereas K concentration was measured using a Flame Photometer (Model: PFP7, Jenway Limited, England).

Statistical analysis

The percentage (%) of mass loss through the green leaves leaching process was arcsine transformed. Mass loss among the species was compared and analysis of variance (Two-Way ANOVA) was calculated using statistical software (SAS 6.12). EC, TDS, Potassium (K), Phosphate (PO_4) and Ammonium (NH_4) concentrations in the collected water of different time intervals were evaluated by ANOVA using statistical software (SAS 6.12). Furthermore, the relationship of leaching time with EC & TDS of the collected leaching water and mass loss of leaf were evaluated by using statistical software (SPSS 17).

Results and Discussion

Mass loss of leaf

The mass loss of green leaves, TDS and EC were significantly ($p < 0.05$) varied among time and species (Table 1). Mass loss variation of green leaves of the studied species may be due to the variable composition of organic and inorganic substances as well as morphological features of leaves of each tree species (Taylor & Parkinson, 1988; Ibrahima et al.,1995; Mahmood et al., 2013).

Table 1. Relationship among mass loss of green leaf, electrical conductivity (EC) and total dissolved solids (TDS) of leaching water and leaching time of selected cropland agroforest tree species (where ML = Mass Loss, EC = Electrical Conductivity, TDS = Total Dissolved Solid, LT = Leaching Time, R^2 = Regression Coefficient, F=value).

Name of species	ML Vs LT Relationship			EC Vs LT Relationship			TDS Vs LT Relationship		
	Equation	R^2	F	Equation	R^2	F	Equation	R^2	F
M. azadirachta	Y=4.70ln(x)+9.66	0.80	57.31	Y=478.9ln(x)+931.7	0.81	60.75	Y=385.7ln(x)+411.5	0.84	76.31
A. indica	Y=4.19ln(x)+3.60	0.77	46.38	Y=503.5ln(x)+444.0	0.81	58.16	Y=377.0ln(x)+279.1	0.80	57.73
D. sissoo	Y=3.44ln(x)+3.25	0.83	68.58	Y=224.1ln(x)+304.3	0.84	72.00	Y=173.4ln(x)+195.7	0.70	32.12
Z. jujuba	Y=2.75ln(x)+5.18	0.78	48.33	Y=2264.8ln(x)+586.6	0.70	39.78	Y=190.5ln(x)+324.1	0.85	77.45
A. saman	Y=1.79ln(x)+7.01	0.65	26.19	Y=234.0ln(x)+328.0	0.82	65.96	Y=187.1ln(x)+185.4	0.72	36.43

Comparatively the highest (35.20%) mass loss was observed for *M. azadirachta* and the lowest (16.03%) was found for *A. saman* at the end of the experiment (Figure 3).

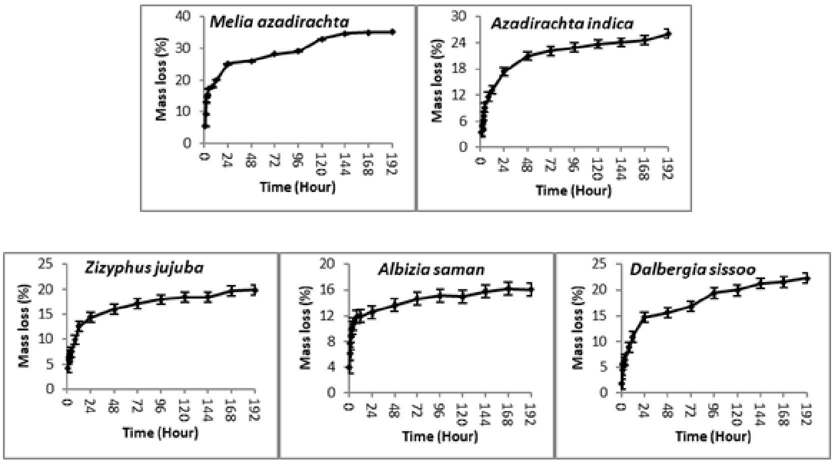

Figure 3. Mass loss (%) at different times of the leaching process.

While, the highest electrical conductivity (3521 µS/cm) was detected for *M. azadirachta* followed by *A. indica* (3380 µS/cm) and the lowest (1526 µS/cm) was for *D. Sissoo* (Figure 4).

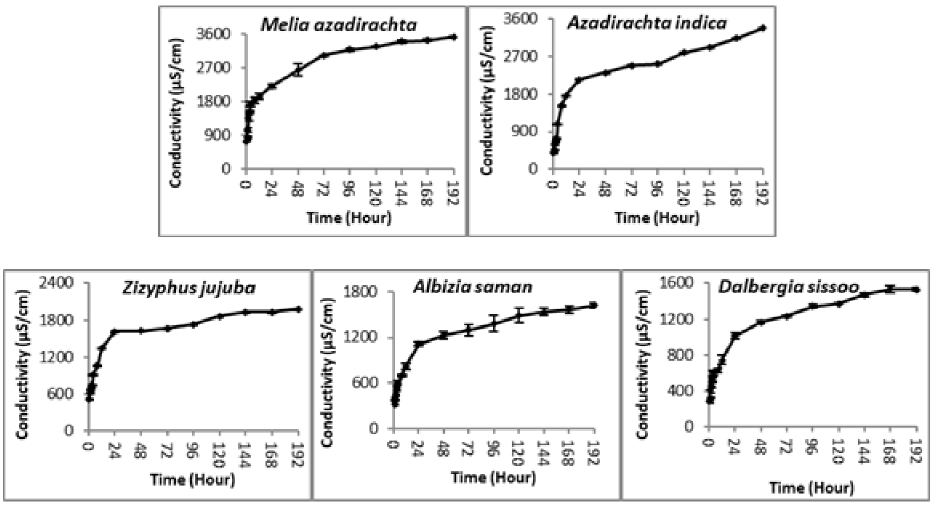

Figure 4. Electrical conductivity (µS/cm) of leaching water at different times of the leaching process.

On the other hand, the highest total dissolved solid (2503 mg/l) was identified for *M. azadirachta* followed by *A. indica* (2407 mg/l) and the lowest (1067 mg/l) was detected for *D. Sissoo* (Figure 5).

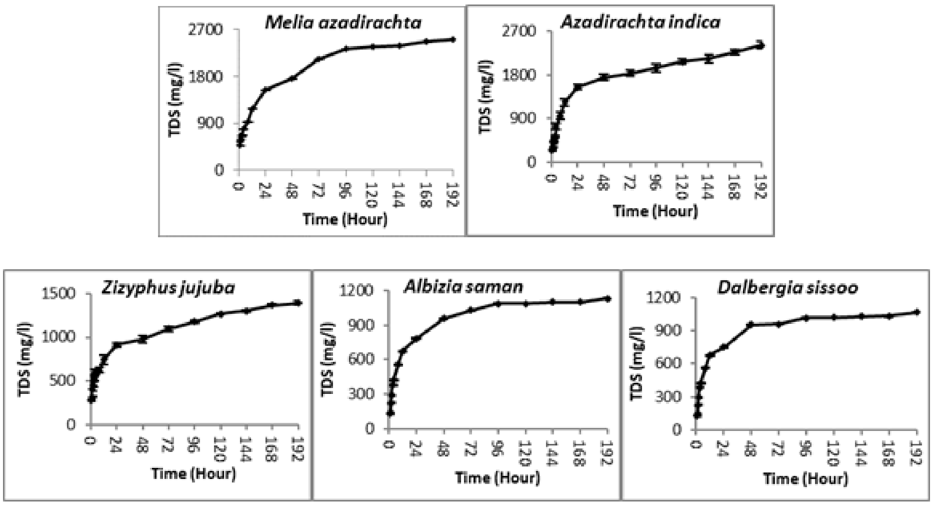

Figure 5. Total Dissolved Solid (mg/l) of leaching water at different times of the leaching process.

Mass loss, TDS and EC showed a positive curvilinear relationship significantly ($p < 0.05$) with leaching time (Table 1). High mass loss of leaves indicates the potentiality of providing readily available nutrients (Wetzel, 1995). On the other hand, the positive curvilinear relationship of leaching time with mass loss, EC and TDS indicates that mass loss can be the result of the release of nutrients which increase with time (Mahmood et al., 2009).

Nutrients released through leaching

Ammonium, Phosphate and Potassium concentrations in the collected leached-out water of the studied species significantly ($p < 0.05$) varied with species and time. The highest concentration (5121 ppm) of NH_4 was observed in the collected water of *M. azadirachta* whereas the lowest (1784 ppm) was for *A. saman* (Figure 6).

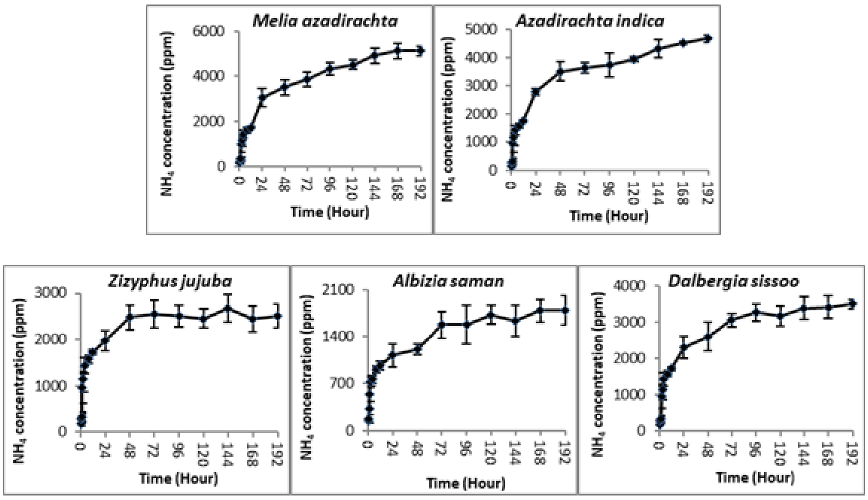

Figure 6. Ammonium concentration (ppm) in leaching water at different times of the leaching process.

The highest concentration (2040 ppm) of PO_4 was found in the collected water of *Z. jujuba* whereas the lowest (1700 ppm) was for *D. sissoo* (Figure 7).

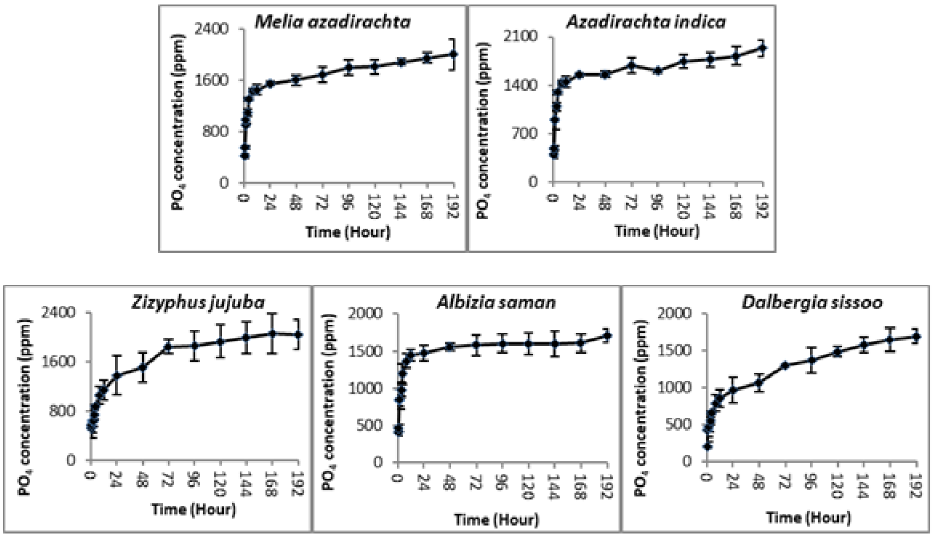

Figure 7. Phosphate concentration (ppm) in leaching water at different times of the leaching process.

The highest concentration (13357 ppm) of K was found in the leaching water of *M. azadirachta* whereas the lowest (5429 ppm) was for *A. saman* (Figure 8).

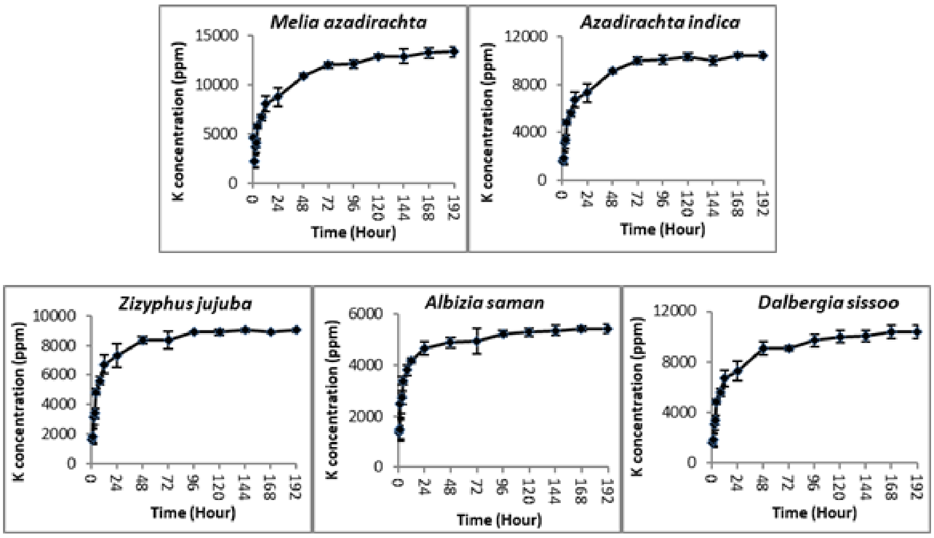

Figure 8. Potassium concentration (ppm) in leaching water at different times of the leaching process.

The comparatively higher portion of potassium (K) was released through leaching followed by NH_4 and PO_4 (Figure 6 - 8) for every studied species. Variation in ammonium (NH_4), phosphate (PO_4) and potassium (K) concentration in collected leaching water among the species may be depended on the initial composition of different substances of leaves of each species (Ibrahima et al., 1995; Mahmood et al., 2013). In addition to this, the rate of leaching of nutrients varies with the individual characteristics of every nutrient as well as their structural involvement in the leaves (Meyer et al., 1973). Rate of nutrients release was higher at the initial stage because of water soluble organic and inorganic substances of leaves are leached quickly whereas, the rate of nutrient leaching process ceased at the later stage for structurally bound components which leach slowly (Kibriya et al., 2019). Ammonium and phosphate concentration in the leaching water was observed to significant ($p < 0.05$) increase for 72 hours at the initial stage but at the later stages (72 to 192 hours) remained almost constant (Figure 6 and 7). While potassium concentration was found to significantly ($p < 0.05$) increased for 48 hours at the initial stage but from 48 to 192 hours (at the later stages) remained almost constant (Figure 8). Mobility of K is very high and presents in the buds, roots and leaves (Marschner, 1995) while nitrogen is a major substance of cell wall which is structurally bound with that (DeFelice, 1993; Smil, 2000) but Phosphorus is mostly available in seeds and fruits whereas lower concentration presents in leaves (Meyer et al., 1973). For this reason, K concentration in leaching water initially rapidly increased in comparison with NH_4 and PO_4 (Marschner, 1995; Mahmood et al., 2009).

Conclusion

The highest nutrient return was observed from green leaves of *M. azadirachta* and lowest was reported for *A. saman* among the studied species. It is believed that, the added nutrients from the green leaf leaching may contribute to the sustainability of soil fertility. *M. azadirachta* and *A. indica* are suitable for agroforestry practices in terms of nutrient return from green leaves. While, *D. sissoo* is found to infested by die-back disease in different areas of Bangladesh. Therefore, this study suggests to prioritize *M. azadirachta* as the best followed by *A. indica* for different agroforestry practices considering the nutrient return.

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Conflicts of Interest

The authors declare no conflict of interest.

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PRELIMINARY PHYTOCHEMICAL SCREENING AND BIOACTIVITY INVESTIGATIONS OF AVORRHEA CARAMBOLA L.

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Abstract
Averrhoa carambola L. (*A. carambola*) is particularly well-known for its distinctive star-shaped fruit (Star fruit), cultivated in Southeast Asia, the Indian subcontinent, and northern and southern America. Historically, it has been used for a long time to cure many ailments, including vomiting, fever, arthralgia, cough, hypertension, hangovers, chronic paroxysmal headache, hyperglycemia, and diabetic nephropathy. This study aimed to examine its preliminary phytochemical and some biological properties. For this, fresh leaves of *A. carambola* were extracted (hot and cold) with ethanol, which was then fractionated with n-hexane and chloroform. Following a preliminary investigation of phytochemicals, radical scavenging, membrane stabilizing, alpha-glucosidase inhibitory, and clot lysis effects were evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, egg albumin model, alpha-amylase assay, and human blood clot lysis assay, respectively using suitable reference standards. The results suggest that *A. carambola* contains alkaloids, glycosides, steroids, tannins, flavonoids, saponins, and reducing sugars. All the organic fractions demonstrated significant ($p < 0.05$) radical scavenging, membrane stabilizing, alpha-glucosidase inhibitory, and clot lysis activities in a concentration-dependent approach. Except for DPPH radical scavenging, the ethanol fraction showed better activities than the n-hexane and chloroform fractions. In summary, *A. carambola* might be a potential source of antioxidant, anti-inflammatory, hypoglycemic, and atherothrombolytic agents. Further studies are required to isolate, characterize, and establish molecular mechanisms for each component's biological effects.

Keywords: *Avorrhea carambola*, free radical scavenging, membrane stabilizing, glucosidase inhibition, clot lysis

Introduction

Since the beginning of civilization, people have used medicinal herbs. According to the World Health Organization (WHO), more than 80% of the earth's population uses natural remedies to manage their health issues, especially the millions who reside in large, isolated areas of developing countries (Mushtaq et al., 2018). Exogenous and indigenous treatments, as well as medicinal plants used to cure a variety of ailments, provide major economic advantages. The finest sources of bioactive molecules may be found in medicinal plants, shrubs, and trees, which are also essential components of the current global healthcare system (Asfaw et al., 2022). Each era experiences an increase in the utilization of plant-based medications, or phytomedicine, since they are safe, have few adverse effects, and work synergistically with other chemicals (Najmi et al., 2022). Several unique substances have been found and synthesized/isolated in contemporary facilities based on conventional techniques, philosophies, beliefs, and recorded or observed treatments across time (Wangkheirakpam, 2018). Many possible bioactive chemicals found in medicinal plants and a variety of foods have been shown to have important health benefits, for examples curcumin, quercetin, rosmarinic acid etc. (Mandal et al., 2022). Additionally, there is growing proof that bioactive substances have the ability to control different gene expressions and treat a number of disease situations, including oxidative stress, inflammation,

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cancer, hypertension, diabetes, and other diseases and disorders (Ortega & Campos, 2019). Various biological actions have been performed against them in both *in-vitro* and *in-vivo* studies (Sharifi-Rad et al., 2021).

Averrhoa carambola L. (*A. carambola*), an evergreen plant of the Oxalidaceae family, is commonly named "Kamranga" in Bangladesh. It is extensively produced in Southeast Asia and the Indian Subcontinent and is also referred to as "star fruit" (Islam et al., 2020). Additionally, it is a well-liked fruit in the markets of the South Pacific Islands, Australia, and the United States (Muthu et al., 2016). *A. carambola* is a kind of woody plant with a moderate growth rate. It has several stems and a small trunk, and it may reach optimum heights of 6 to 9 m. It has a bushy look with numerous branches that form a wide, spherical crown and a trunk base that can be up to 15 cm in diameter (Kapoor, 2018). Aside from having leaflets that fold together at dusk, the tree also exhibits sensitivity to light and shock through the sudden movements of its leaves. Small clusters of five-petaled red, lilac, or purple blooms are produced by the starfruit's shrub. Unripe fruits are often tiny and dark green; while, fully ripe fruits have a golden color. Typically, starfruits have five longitudinal ridges or angles, are juicy, and have a crunchy, crisp quality. Additionally, the fruit is known as "star fruit" because it has a star shape when cut horizontally (Muthu et al., 2016).

Herbal remedies are currently gaining popularity as an alternative to pharmacological therapy on a global scale (Lippert & Renner, 2022). Star fruits are used as a food source as well as an herb in various regions of Brazil, China, India, Malaysia, and Taiwan (Patel et al., 2015). In addition, it is also used in Ayurvedic and Traditional Chinese Medicine systems for the treatment of fever, cough, respiratory diseases, chronic paroxysmal headache, and epidermal inflammations (Wang et al., 2016). Various plant parts, including fruits, leaves, and stems, have been revealed to have pharmacological properties. According to phytochemical and pharmacological research, the extracts of the star fruit plant's leaves, fruits, and roots may include saponins, steroids, flavonoids, glycosides, alkaloids, carbohydrates, and tannins, all of which are reported to have antioxidant and particular therapeutic effects (Annegowda et al., 2012; Saikia et al., 2015). It has been demonstrated that the plant has biological properties that are anti-inflammatory, antioxidant, antimicrobial, and anti-ulcer (Dasgupta et al., 2013). Additionally, the high fiber content of fruits helps to absorb glucose while delaying its absorption into the bloodstream, which helps to regulate blood glucose levels (Wu et al., 2009). As it facilitates the elimination of cholesterol, lipids, and bile acid through excretion, starfruit consumption also has a hypocholesterolemic and hypolipidemic effect (Ferreira et al., 2008).

This study aimed at a preliminary phytochemical investigation along with the screening of free radical scavenging, membrane stabilizing, alpha-glucosidase inhibitory, and clot lysis effects of *A. carambola*'s organic extracts.

Materials and Methods

Collection, identification, grinding, and extraction of plant materials

Throughout June and July, fresh leaves were collected from the Sitakunda Eco Park's hill tracts in Chattagram. The leaves were then cleansed with running tap water. After that, the plant components were dried under the shade (at a temperature not going beyond 40 °C). The plant was recognized by the taxonomist at the Bangladesh Forest Research Institute Herbarium (BFRIH), Chattagram. A voucher sample was submitted as SA (525). Thereafter, the dried plant components were crushed into a coarse powder and maintained in an airtight container in a dry, cold, and dark location until the extraction process started.

In an amber-colored glass bottle, 800 ml of absolute ethanol was added to 200 g of coarse powder. It was closed and occasionally agitated. The mixture was filtered after 20 days using Whatmann filter paper no 1 after first passing through a cotton plug. The Soxhlet device performed a hot extraction on the marc that was recovered from the maceration process. Briefly, in a Soxhlet device (Quickfit, England), 1000 ml of absolute ethanol and 140 g of marc were combined. The resulting extract was collected, filtered, and subjected to a process that caused the solvent to evaporate below 60 °C.

Fractionation of crude extract

The procedure developed by Abubakar and Haque (2002) was used for solvent-solvent partitioning. Briefly, the crude ethanol extract (EAC: 18 g) was diluted in double-distilled water (DDW) and afterward fractionated using a fractionating column with n-hexane (HAC), and finally with chloroform (CAC). Until 150 ml of n-hexane and chloroform were produced, fractionation was performed using 50 ml of solvent each time, and after each fractionation, the mixture was vigorously shaken before being left to stand. Layers of solvent were divided and decanted. The leftover extract was used as an ethanol fraction (EAC). The extracted materials were collected, filtered, and driven to have the solvent evaporate at a temperature below 50 °C. A sticky concentration was produced as a result of solvent evaporation. The sticky extracts were weighed and preserved in an airtight, clean, appropriately labeled container at 4 °C. Figure 1 shows the fractionation procedures of EAC of *A. carambola*.

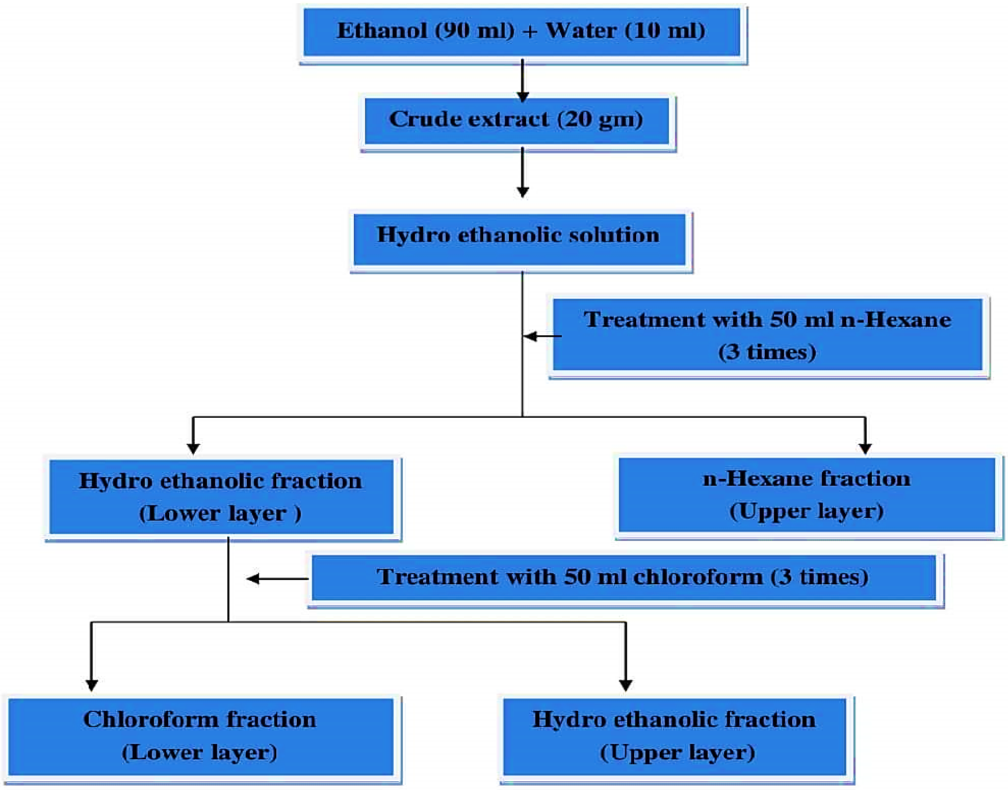

Figure 1. Schematic presentation of fractionation process of crude ethanol extract of *Averrhoa carambola*

Reagents and chemicals

Ethanol, n-hexane, chloroform, ascorbic acid, alpha-amylase, and DPPH were purchased from Merck India, while diclofenac sodium and acarbose were kindly provided by Square Pharmaceuticals Ltd. and Pacific Pharmaceuticals Ltd., both in Bangladesh. Streptokinase (Durakinase Injection; powder for reconstitution; 30,000 units per vial) was imported from Dong Kook, Korea.

Phytochemical screening

Preliminary phytochemical studies were done according to the method described by Islam (2021).

Free radical scavenging test (DPPH assay)

With a few minor adjustments, this investigation was carried out using the methodology outlined by Valko et al. (2007). Briefly, 0.5% tween-80 dissolved in normal saline was used as a vehicle to prepare all the fractions and the standard medication ascorbic acid (AA) at 20, 40, 60, 80, and 100 µg/ml. In methanol, a 0.24% DPPH solution was prepared. 100 µl of test or control solution are included in 3 ml of adequately mixed DPPH solution, which is then kept in dark for 30 minutes. A spectrometer (Shimadzu, Japan) was used to measure the absorbance at 517 nm, and the following equation was used to calculate the percentage of the radical scavenging capability of the test or control samples:

$$\%\text{Scavenge of free DPPH radicals} = \frac{(\text{Ac}-\text{At/s})}{\text{Ac}} \times 100$$

Where, Ac and At/s mean absorbance of control and test or standard, respectively.

The IC_{50} (the concentration needed to suppress 50% of the enzymatic activity) was estimated using a regression equation derived by plotting concentrations in the range of 20–100 µg/ml (x-axis) and inhibition (y-axis) for several treatments.

Membrane stabilization test (Egg albumin assay)

This experiment was carried out with a few minor adjustments to the procedure outlined by Mehta et al. (2017). In a summary, a 5 ml reaction mixture contained 2 ml of test or control samples, 2.8 ml of phosphate buffer (PBS, pH 6.4), and 0.2 ml of egg albumin. The standard (diclofenac sodium, DCLO) and test (EAC, CAC, and HAC) were examined at the same concentration as described in the preceding research. For this aim, the identical vehicle was also utilized as a control. The reaction mixtures were then incubated for a further 15 min at 37.2 °C and a further min at 70 °C. After that, a colorimeter was used to quantify the optical density at 660 nm. The following formula was used to calculate the percentage inhibition of protein denaturation:

$$\%\text{Inhibition of egg albumin denaturation} = 100 \times \frac{1-(OD_2-OD_1)}{(OD_3-OD_1)}$$

Where, OD_1, OD_2, and OD_3 mean the optical densities of test (unheated), test (heated), and control (heated), respectively.

The IC_{50} (the concentration needed to suppress 50% of the enzymatic activity) was estimated using a regression equation derived by plotting concentrations in the range of 20–100 µg/ml (X-axis) and inhibition (Y-axis) for several treatments.

Glucosidase inhibitory test (Alpha-amylase assay)

With a few minor adjustments, this analysis was carried out in accordance with Pistia-Brueggeman and Hollingsworth (2001). In a brief, 50 µl of fractions or standards, such as acarbose (ACB) at different concentrations (20-100 g/ml), were incubated for 20 min at 37 °C with 10 µl of the -glucosidase (maltase) enzyme solution, along with 125 µl of 0.1 M PBS (pH 6.8). The addition of 20 µl of 1 M pNPG (substrate) to the reaction was made after 20 min had elapsed, and the mixture was then incubated for 30 min. A colorimeter was used to determine the final optical density at 405 nm after the reaction was stopped by the addition of 0.1 N of Na2CO3 (50 µl). The vehicle described before operated as an NC. Enzyme activity was analyzed as follows:

$$\%\text{Inhibition of alpha-amylase} = \frac{OD_B - OD_{T/S}}{OD_B} \times 100$$

Where, OD_B and $OD_{T/S}$ mean the optical densities of blank and test/standard, respectively.

The IC_{50} (the concentration needed to suppress 50% of the enzymatic activity) was estimated using a regression equation derived by plotting concentrations in the range of 20–100 µg/ml (x-axis) and inhibition (y-axis) for several treatments.

Anti-atherothrombosis test (Clot lysis assay)

This project using human sample was approved by the Ethical Committee (SUB/IAEC/12.01). With a few minor changes, this experiment was carried out by the procedure outlined by Hussain et al. (2014). In a brief, 10 healthy participants of either sex had their venous blood collected, and the blood was then promptly distributed to pre-weighed, sterile micro-centrifuge tubes (500 µl blood/tube, 10 tubes for test or control). The tubes received 200 µl of 2% calcium chloride, were thoroughly mixed, and incubated for 45 min at 37°C to promote clotting. The serum was entirely withdrawn after that (without disrupting the clot), and the clot's weight was determined (weight of the clot-containing tube minus the weight of the tube alone). Marked tubes received 500 µl of the test or control solution, which was then incubated again at 37 °C for 90 min. The tubes labeled "control" were treated with the aforementioned vehicle and 30,000 IU of streptokinase (STK). Following the incubation period, the fluids that had been lysed were meticulously collected and weighed once again to calculate the percentage of clot lysis, as shown below:

%Clot lysis = (Weight of the clot after lysis by test or controls and removal of serum ÷ Weight of the clot before lysis by test or controls) × 100

Statistical analysis
The values are mean ± SD (standard deviation). One-way analysis of variance (ANOVA) followed by the *t*-student test. GraphPad Prism (version 6.5) is used to analyze the data. Values are considered significant when $p < 0.05$ at 95% confidence intervals.

Results
Extraction and fractions
Cold and hot extraction processes resulted in yields of 10 and 8 g (total 18 g), respectively. The percentage yield values for EAC, CAC, and HAC were 2.132, 2.05, and 3.276 g, respectively.

Phytochemical group test
The EAC contains glycosides, alkaloids, tannins, saponins, and flavonoids, whereas the CAC contains glycosides, tannins, and flavonoids. On the other hand, HAC possesses glycosides, tannins, flavonoids, saponins, and reducing sugars. There are no gums or amides in any of the fractions.

Table 1. Phytochemical groups observed in different fractions of *Averrhoa carambola*

Extracts	Phytochemical groups						
	Alkaloids	Glycosides	Steroids	Tannins	Flavonoids	Saponins	Reducing sugars
EAC	-	+	-	++	+++	+	+
CAC	+	+++	-	+	+	-	-
HAC	-	++	-	+	+	+	+

'+' = present, '-'= absent; multiplication of plus (+) sign means observed intensity of observation; EAC: ethanol extract of Averrhoa carambola; CAC: chloroform extract of Averrhoa carambola; HAC: n-hexane extract of Averrhoa carambola

Free radical scavenging test (DPPH assay)
The control (NC) exhibited negligible DPPH scavenging capacity (1.23±0.86). All the fractions exhibited significant ($p < 0.05$) concentration-dependent radical scavenging effects on DPPH radicals, where at 100 µg/ml EAC, CAC, and HAC showed percent inhibition of 40.42±2.91, 63.97±1.22, and 59.35±2.13%, respectively. AA at the same concentration also exhibited a significant ($p < 0.05$) percent inhibition of 83.37±1.09%. The IC_{50} determined for EAC, CAC, HAC, and AA were 48.01±1.23, 62.29±2.13, 78.92±1.67, and 21.53±2.13 µg/ml, respectively. CAC exhibited a better DPPH radical scavenging effect than the other fractions. However, the standard antioxidant AA exhibited a better radical scavenging effect than all fractions of *A. carambola* (Table 2).

Table 2. DPPH radical scavenging capacity of different fractions of *Averrhoa carambola* and controls

μg/ml	Percentage DPPH radical scavenge				
	NC	EAC	CAC	HAC	AA
20	1.23±0.86	40.42±1.08*	33.03±1.19*	19.86±1.78*	49.42±1.23*
40		47.34±2.18*	43.42±0.58*	28.41±1.53*	56.58±1.17*
60		58.19±0.78*	49.88±1.87*	42.49±2.13*	68.59±2.13*
80		67.21±1.13*	55.66±1.78*	53.35±2.09*	77.37±1.08*
100		40.42±2.91*	63.97±1.22*	59.35±2.13*	83.37±1.09*
IC_{50}	-	48.01±1.23	62.29±2.13	78.92±1.67	21.53±2.13

*Values are mean ± SD (standard deviation) (n = 5); *p <0.05 when compared to the NC group; DPPH: 2,2-diphenyl-1-picrylhydrazyl; EAC: ethanol extract of Averrhoa carambola; CAC: chloroform extract of Averrhoa carambola; HAC: n-hexane extract of Averrhoa carambola; NC: vehicle (0.5% tween-80 dissolved in normal saline); AA: ascorbic acid; IC_{50}: half maximal inhibitory concentration*

Membrane stabilization test (Egg albumin assay)

The NC produced negligible membrane stabilizing capacity (1.39±0.78%). All the fractions exhibited significant (p <0.05) concentration-dependent inhibitory effects on egg protein denaturation, where at 100 μg/ml EAC, CAC, and HAC showed percent inhibition of 76.91±1.09, 65.72±1.22, and 62.44±2.13%, respectively. DCLO at the same concentration also exposed a significant (p <0.05) percent inhibition of 89.22±2.91%. The IC_{50} determined EAC, CAC, HAC, and DCLO were 39.63±1.20, 76.78±2.13, 79.62±1.67, and 30.05±1.03 μg/ml, respectively. EAC revealed a better inhibitory result than the other fractions. However, the standard drug DCLO showed a better inhibitory outcome than all fractions of *A. carambola* (Table 3).

Table 3. Membrane stabilization capacity of different fractions of *Averrhoa carambola* and controls

μg/ml	Percentage inhibition of protein denaturation				
	NC	EAC	CAC	HAC	DCLO
20		37.67±1.23*	32.26±1.19*	21.22±1.78*	42.26±1.08*
40		50.62±1.17*	40.97±0.58*	31.29±1.53*	55.35±2.18*
60	1.39±0.78	58.29±2.13*	48.67±1.87*	42.59±2.13*	63.22±0.78*
80		70.19±1.08*	57.67±1.78*	51.10±2.09*	76.13±1.13*
100		76.91±1.09*	65.72±1.22*	62.44±2.13*	89.22±2.91*
IC_{50}	-	39.63±1.20	76.78±2.13	79.62±1.67	30.05±1.03

*Values are mean ± SD (standard deviation) (n = 5); *p <0.05 when compared to the NC group; EAC: ethanol extract of Averrhoa carambola; CAC: chloroform extract of Averrhoa carambola; HAC: n-hexane extract of Averrhoa carambola; NC: vehicle (0.5% tween-80 dissolved in normal saline); DCLO: diclofenac sodium; IC_{50}: half maximal inhibitory concentration*

Table 4. Alpha-amylase inhibition capacity of different fractions of *Averrhoa carambola* and controls

μg/ml	Percentage alpha-amylase activity inhibition				
	NC	EAC	CAC	HAC	ACB
20	1.56±0.53	39.61±1.23*	33.07±1.19*	7.88±1.78*	42.96±1.08*
40		49.35±1.17*	41.07±0.58*	20.30±1.53*	53.27±2.18*
60		58.44±2.13*	51.73±1.87*	30.00±2.13*	62.89±0.78*
80		65.91±1.08*	60.80±1.78*	40.61±2.09*	78.01±1.13*
100		79.55±1.09*	70.93±1.22*	51.82±2.13*	94.85±2.91*
IC_{50}	-	44.77±1.20	57.59±2.13*	99.19±1.67	27.56±1.03

Values are mean ± SD (standard deviation) (n = 5); EAC: ethanol extract of Averrhoa carambola; CAC: chloroform extract of Averrhoa carambola; HAC: n-hexane extract of Averrhoa carambola; NC: vehicle (0.5% tween-80 dissolved in normal saline); ACB: acarbose; IC_{50}: half maximal inhibitory concentration

Glucosidase inhibitory test (Alpha-amylase assay)

The NC produced negligible glucosidase inhibitory capacity (1.56±0.53%). All the fractions exhibited significant ($p < 0.05$) concentration-dependent inhibitory effects on the alpha-amylase enzyme, where at 100 μg/ml EAC, CAC, and HAC showed percent inhibition of 79.55±1.09, 70.93±1.22, and 51.82±2.13%, respectively. ACB at the same concentration (100 μg/ml) also presented significant ($p < 0.05$) percent inhibition of 94.85±2.91%. The IC_{50} determined EAC, CAC, HAC, and ACB were 44.77±1.20, 57.59±2.13, 99.19±1.67, and 27.56±1.03 μg/ml, respectively. EAC displayed a better inhibitory activity than the other fractions. However, the standard drug ACB revealed a better inhibitory property than all fractions of *A. carambola* (Table 4).

Anti-atherothrombosis test (Clot lysis assay)

Table 5 suggests that the control (NC) group exhibited negligible (1.94±0.79%) clot lysis capacity. The standard drug STK showed a significant ($p < 0.05$) and highest clot lysis capacity of 81.54±1.11%. Among the organic fractions, EAC exhibited better clot lysis capacity (19.93±0.86%), then followed by CAC (12.78±0.46%) and HAC (7.05±0.35%). However, the activity is poor when compared to the STK.

Table 5. Clot lysis capacity of different fractions of *Averrhoa carambola* and controls

Treatments	Percentage clot lysis
NC (vehicle)	1.94±0.79
STK	81.54±1.11*
EAC	19.93±0.86*
CAC	12.78±0.46*
HAC	7.05±0.35*

*Values are mean ± SD (standard deviation) (n = 10); *p <0.05 when compared to the NC group; EAC: ethanol extract of Averrhoa carambola; CAC: chloroform extract of Averrhoa carambola; HAC: n-hexane extract of Averrhoa carambola; NC: vehicle (0.5% tween-80 dissolved in normal saline); STK: streptokinase*

Discussion

Ethanol, chloroform, and n-hexane are frequently used for the extraction of compounds present in plants. Hydrophilic compounds are extracted with ethanol, methanol, or ethyl acetate, while lipophilic compounds are extracted using chloroform, dichloromethane, or a mixture of dichloromethane/methanol. On the other hand, n-hexane is used to remove chlorophyll from plant extracts (Cosa et al., 2006). For initial extraction, chloroform is used for dried plant materials. However, this solvent is frequently used to extract glycosidal contents from the crude samples (Onwukaeme et al., 2007). To date, approximately 132 phytoconstituents have been isolated from *A. carambola*. Among them, glycosides, flavonoids, and benzoquinones are evidently bioactive (Luan et al., 2021). Our preliminary phytochemical report suggests that EAC showed high intensities for tannins and flavonoids, while CAC and HAC showed high intensities for glycosides.

The DPPH test is a straightforward and accurate way to assess the capacity of a stable free radical called DPPH (2,2-diphenyl-1-picrylhydrazyl) to decolorize when antioxidants are present (Bao et al., 2020). It is a rapid and efficient colorimetric technique that works by reducing DPPH radicals in the presence of a proton donor material, which produces diamagnetic molecules (Diniso et al., 2022). For this test, AA was used as the standard antioxidant. The absorbance at 515 to 517 nm as well as the apparent deep purple color are caused by the odd electron that the DPPH radical possesses. The amount of decolorization caused by DPPH accepting an electron given to it by an antioxidant chemical may be calculated from changes in absorbance (Hasan et al., 2009). Phenolic chemicals such as polyphenols, tannins, flavonoids, and phenolic terpenes have a significant influence on the antioxidant property of plant products (Nguyen et al., 2020). The major source of phenolic chemicals' antioxidant action is their redox characteristics, which can be useful for adsorbing and neutralizing free radicals, reducing singlet and triplet oxygen, or dissolving peroxides (Laouicha et al., 2020). Moreover, research evidence suggests that the plant contains high levels of vitamin C (25.8 mg/100 g fruit) (Muthu et al., 2016). One study reports that *A. carambola extract at* 0.1–375 μg/ml showed significant DPPH radical scavenging capacity, where IC_{50} was calculated at 55.55 to 100.0 μg/ml (Liao et al., 2019; Islam et al., 2020; Siddika et al., 2020). In this study, we have seen that all the fractions exhibited DPPH radical scavenging capacity within the IC_{50} values 48.01±1.23 and 78.92±1.67 μg/ml, suggesting agreement with the previous reports. A variety of human neurological and other diseases, including inflammatory responses, viral infections, immunological abnormalities, and digestive tract disorders like GI inflammation and ulceration, currently seem to be caused by oxidative stress as their core mechanism (Aruoma, 2003). Comparable to this, in the complex phases of carcinogenesis, reactive oxygen species (ROS) begin with DNA damage and the accumulation of genetic alterations through one or multiple cell lines, which progress to dysplastic cellular appearance, uncontrolled cell proliferation, and ultimately cancer (Saretzki, 2010). Therefore, treatment with antioxidants that scavenge free radicals can prevent, postpone, or improve many of these diseases (Akbari et al., 2022). A growing amount of data from epidemiological and clinical investigations over the last two decades has shown that several plants or their recognized antioxidant-rich components have significant inhibitory impacts on human carcinogenesis (Hasan et al., 2009). According to the current findings, *A. carambola* may play a part in the biological action of antioxidants. DPPH radicals were significantly scavenged by the EAC, CAC, and HAC as compared to the AA reference standard at a concentration of 100 μg/ml. Compared to the other fractions, CAC showed a stronger ability to scavenge DPPH radicals. The results of the experiment show that plant extracts have modest antioxidant action. Studies demonstrate that glycosides are promising natural antioxidants (Kumar et al., 2010; Wen et al., 2017). Our phytochemical reports suggest that CAC showed stronger intensities for glycosides.

The *in-vitro* anti-denaturation technique of egg albumin was adopted to assess the anti-inflammatory properties of *Averrhoa carambola*. The egg albumin is heated to a high temperature during the anti-denaturation technique test. Denatured proteins can express certain antigens. These antigens are linked to hypersensitivity responses (type-III), which are linked to a number of illnesses such as serum sickness and glomerulonephritis (Usman & Annamaraju, 2021). Proteins that have been heated up can cause delayed hypersensitivity. These proteins are just as effective as native proteins at stimulating cells (Yesmin et al., 2020). Furthermore, it has previously been established that traditional NSAIDs like diclofenac sodium reduce protein denaturation in addition to preventing the generation of endogenous prostaglandins by inhibiting the cyclooxygenase (COX) enzyme (Aidoo et al., 2021). Our results showed that EAC, HAC, and CAC, inhibited protein denaturation significantly as compared to the control group. The extracts at 100 μg/ml demonstrated appreciable anti-inflammatory action compared to the equivalent standard (DCLO) concentration. EAC revealed a better inhibitory result than the other fractions. Phytochemicals like alkaloids and flavonoids can give the plant its anti-inflammatory properties (Truong et al., 2019). Additional secondary metabolites produced by plants, such as terpenoids and glycosides, may potentially have anti-inflammatory activities (Shazhni et al., 2018). It is also evident that oxidative stress leading to inflammation or *vice versa* may lead to excessive tissue damage, which thereby results in numerous diseases and disorders in humans (Khansari et al., 2009). Therefore, the strong antioxidant capacity of *A. carambola* might be linked to its promising anti-inflammatory effect (in-vitro) in this present study.

A large number of medicinal herbs have been linked to antidiabetic action, which is regulated by a variety of mechanisms, including higher pancreatic insulin production, suppression of glucose absorption, and accelerated glucose uptake by muscles and adipose tissue (Elwekeel et al., 2022). The suppression of enzymes that metabolize carbohydrates, such as α-glucosidase and α-amylase, is another significant strategy recognized for the control of diabetes (Zhang et al., 2022). The conversion of oligosaccharides and disaccharides into monosaccharides, which may be transported through the intestinal mucosa and into the circulation, is carried out by these enzymes (Aggarwal et al., 2022). As a result of the suppression of α-glucosidase and α-amylase, blood glucose levels drop later than expected, which is followed by a reduction in insulin production (El-Manawaty & Gohar, 2018). In this investigation, the inhibitory impact of A. carambola extract against α-glucosidase enzyme was examined. When compared to standard ACB (IC50 = 94.85±2.91 μg/ml), the EAC (IC50 = 79.55±1.09 μg/ml) demonstrated strong inhibitory action against the α-amylase enzyme. A possible putative explanation for the A. carambola extract's strong hypoglycemia impact was identified by a literature review as having comparable α-amylase inhibitory actions (Chen et al., 2015; Hung et al., 2012). These findings imply that the inhibitory impact against enzymes that break down carbohydrates may be a potential mechanism for the anti-diabetic properties of A. carambola, suggesting that this plant's antidiabetic activity may include several targets.

One of the leading causes of morbidity and death around the globe is atherothrombosis, which is defined by the development of one or more atheromatous plaques within the blood vessels (Martin-Ventura et al., 2017). The clot-filled blood inside the arteries is lysed using fibrinolytic chemicals. Beta-hemolytic *Streptococci* bacteria release the extracellular fibrinolytic enzyme known as streptokinase, which is used frequently since it is inexpensive (Sikder et al., 2022). Herbal products may have anti-thrombotic properties, according to a body of research. It is clear that secondary metabolites originating from plants, such as polyphenols, alkaloids, and glycosides, have an anti-atherothrombotic effect (Olatunji et al., 2017; Zhu & Fang, 2014). In order to dissolve the clots in the blood vessels, it first forms a complex by connecting to both free and fibrin-bound plasminogen. After that, the complex converts the other free plasminogen into an active protease plasmin (Li et al., 2020). This medication is most frequently used to treat pulmonary embolism, deep vein thrombosis, and acute myocardial infarction (Dundar et al., 2003). Our research shows that *A. carambola* extracts have a considerable, concentration-dependent capability for clot lysis. According to research, there is potential for curing atherosclerosis by using medicinal herbs to lower cholesterolemia, free radicals, inflammatory diseases, and critical enzymes (Sedighi et al., 2017). Furthermore, the medicinal herb may be a great tool for treating individuals with hyperlipidemia and associated problems, either by itself or in conjunction with hypocholesterolemic medications (Wang et al., 2017).

Conclusion

This study reports that *A. carambola* possesses many important phytochemical groups, including alkaloids, glycosides, tannins, saponins, and flavonoids. It had significant DPPH radical scavenging, egg albumin stabilizing, and alpha-glucosidase inhibitory effects that were concentration dependent. However, it exhibited poor clot lysis capacity. We suppose that our observed bioactivities might be due to the presence of some important phytochemical groups, especially the glycosides and flavonoids in its fractions. The herb might be a potential source of antioxidant, anti-inflammatory, and anti-diabetic agents. Further research is required to isolate and characterize its bioactive components and elucidate the possible action mechanism for each of its bioactivities.

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Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE **LIFE SCIENCE**

SCREENING OF AGGLUTINATION ACTIVITIES OF COMMON VEGETABLES IN BANGLADESH

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Abstract

Lectins are capable of cell agglutination by interacting with the cell surface exposed glycans. Lectins that agglutinate erythrocytes are called hemagglutinin. These compounds occur in various organisms including plants. In this study, twenty edible vegetables were subjected to screen for haemagglutination and lectin activity. Lectin activity was assessed by measuring the inhibition ability of haemagglutination by different sugars. PBS (Phosphate Buffer Saline) treated homogenate was tested for haemagglutination against erythrocytes suspension, and inhibition of agglutination was determined by serially diluted sugar solution. The results of this study demonstrated that one homogenate among the homogenates of 20 vegetables was found to be capable of human erythrocyte agglutination. The Ipomoea aquatica homogenate shown positive haemagglutination reaction against red blood cells (RBCs) with HA titer value of 4 HA-U/25uL, and four out of seven sugars were able to inhibit RBCs agglutination. Among the four sugars, two are potent inhibitors of agglutination. The neutralization of haemagglutination by four monosaccharides provides a suggestion that the lectin present in I. aquatica may be multivalent carbohydrate binding hemagglutinin. This is the first report to identify that Ipomoea aquatica contains lectin protein which is a polyvalent sugar binding lectin and specific for glucose, galactose, *mannose and N-Acetyl-D-Glucosamine.*

Keywords: Vegetables, haemagglutination, lectin, erythrocytes, sugar specificity

Introduction

'Hemagglutinin' or 'lectin' named by Boyd and Shyleigh, was discovered for the first time by Stillmark in 1888 (Boyd, 1963). Lectins that can agglutinate RBCs are called hemagglutinins. However, this is an oversimplification because all hemagglutinins cannot agglutinate erythrocytes. Reversible binding of cell surface sugar is exclusive for lectins (Hassan et al., 2015). A well-established haemagglutination inhibition assay was utilized in this research for the purpose of screening hemagglutinins (Hirst, 1942). Plant lectins have been sectioned, conferring their specificity of carbohydrate binding. Based on this specificity, mannose, mannose/glucose, mannose/maltose, Gal/GalNAc, GlcNAc/(GlcNAc)n, fucose, and sialic acid binding lectins have been distinguished (Goldstein & Poretz, 1986; Van Damme et al., 1998). Rapid progress in structural analysis of lectins and detailed sequence information of lectins provides a tool for determining lectins in seven families with legume lectins, monocot mannose-binding lectins, chitin-binding lectins, type 2 rip, and related lectins, jacalin-related lectins, amaranthine lectin, and Cucurbitaceae phloem lectins husking (Damme et al., 1998). Each family of lectins has some physiologic role. Legume lectins (LL) acts like plant defense proteins when insects invade them (Damme et al., 1998). Similarly, jacalin related lectins (JRL), Amaranthin lectins (AL), and Cucurbitaceae phloem lectins (CPL) family are also involved in plant defense (Damme et al., 1998). Hemagglutinin or lectin has garnered attention in medical research and therapy because lectin-based approaches are becoming more popular in novel cancer biomarker research. Lectins are a valuable tool for investigating different cellular processes of cell signaling using the fluorescent-protein biosensors technique (Giuliano & Taylor, 1998). Lectins, for their carbohydrate-binding affinity, can inhibit enveloped viruses from attachment and fusion with the target cell membrane. Lectins also play a role in the study of immunomodulatory effects. *Agaricus bisporus* lectins (ABL) has shown potential action against autoimmune inflammatory pathologies (Ditamo et al., 2016). Lectins could be used

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as carrier molecules to target drugs specifically to different cells and tissues, as other cell types express different glycan arrays, particularly in diseased cells. Several lectins are now used in lectin-mediated drugs targeting in lung, blood brain barrier (BBB), and eye (Bies et al., 2004).

Bangladesh is an agriculture-based country. Most of the selected plants are used traditionally for the management of different diseases including pain, splenic disorders, cholera, dysentery, asthma, cough, bronchitis, hypertension and no report are available on HA activity of the selected plants except seeds of *Amaranthus spinosus, Piper longum L, Moringa oleifera* and *Cucurbita pepo* (Hussain et al., 2010; Kumar et al., 2012; Kumar et al., 2014; Mandelker et al., 2009; Meira et al., 2012; Metha & Belemkar, 2014; Ratnam et al., 2017; Shavandi et al., 2012; Tanmoy et al., 2014; Tripathi et al., 1999). Previous studies reported pharmacological activity including antitumor, antioxidant, anti-inflammatory, antifungal, antibacterial, cytotoxic, hepatoprotective, anti-cancer, anthelmintic, anti-proliferative activity of multiple plants utilized in this research (Ali et al., 2012; Bezerra et al., 2013; Bhatia & Jain, 2004; Huang et al., 2005; Hussain et al., 2011; Kolya et al., 2015; Maeda et al., 2008; Samojlik et al., 2010; Sannigrahi et al., 2010; Shokrzadeh et al., 2010). As these plants possess multiple pharmacological activities, the selected plants are an interesting candidate for the present screening study of haemagglutination activity (HA) or lectin activity, as lectins also possess antitumor, antiproliferative and immunomodulatory activities (Hassan et al., 2015), anthelmintic (Ríos-de Álvarez et al., 2012), antibacterial, antifungal, antiviral (Paiva et al., 2010; Peumans & Van Damme, 1995), antioxidant, anticancer, antitumor (Dhuna et al., 2005; Saha et al., 2014; Zhang et al., 2015), cytotoxic activity (Ribéreau-Gayon et al., 1995).

The aim of this paper is to dive deep into understanding if regular vegetables do possess lectin activity or not because their traditional uses indicate that they might. Documented research to back up these traditional reports can pave the way for future utilization of these plants in a more informed and formal manner. Lectins were previously reported to have benefits of ameliorating cardiovascular diseases, type 2 diabetes, and other detrimental health complications (Kolb et al., 1986; Pągowska-Klimek & Cedzyński, 2014). Thus, findings of these papers can also promote utilizing these highly available food sources for overall positive physiological outcomes.

Materials and Method

Validation of method

After setting a working protocol by reviewing several literatures, validation of the working method was done to ensure that the active protocol was suitable for driving the thesis. *Lens culinaris* was used as a working standard control for running HA assay and HA inhibition assay. It was chosen as the standard because lens culinaris agglutinin (LCA) agglutinates human erythrocytes of all ABO types equally well (Heritage, 1973). Mannose sugar was used for inhibition assay (Yamamoto et al., 2000).

Collection of samples

In this investigation, selected 20 vegetables (*Spinacia oleracea, Ipomoea aquatica, Typhonium trilobatum L., Amaranthus spinosus, Alternanthera Sessilis R. Br., Piper longum L., Amaranthus gangeticus, Amaranthus viridis L, Eryngium foetidum, Cucurbita pepo, Bacopa monnieri, Desmodium triflorum, Moringa oleifera, Enhydra fluctuans, Coriandrum sativum L, Hygrophila auriculata, Rumex acetosa, Trianthema portulacastrum, Alternanthera philoxeroides and Cinnamomum tamala*) were collected from local market of Khulna, Bangladesh to screen them for possible haemagglutination or lectin activity. These samples are from fourteen different families, including Acanthaceae, Aizoaceae, Amaranthaceae, Apiaceae, Araceae, Asteraceae, Convolvulaceae, Cucurbitaceae, Lauraceae, Leguminoseae, Moringaceae, Piperaceae, Plantaginaceae, Polygonaceae. All samples were collected prior to the test with a view to confirming that fresh vegetables were used. Each sample was stored at frozen condition before analysis. For this screening study, leaves, stems and leafy parts of all selected plants were used.

Preparation of PBS

PBS (Phosphate Buffer Saline) was prepared with a pH of 7.4 (Rouf et al., 2011) and stored in the refrigerator. Before using PBS, pH was checked by hana pH meter.

Sample Homogenization

Immediately after defrosting 6-10g of sample was homogenized on ice in PBS of pH with 7.4 and 2mL PBS was used for per gram of sample to be homogenized (Rouf et al., 2011). After 25-30 minutes homogenization the homogenate was subjected to blending in jaipan heavy duty blender machine for 5-10 minutes. The homogenate was left for overnight homogenization on a magnetic stirrer, ensuring cool temperature condition and was filtered at the following day using cotton gauge. After centrifuging the filtrate at 1500 RCF for 20 minutes at 4°C temperature, the supernatant was collected, and centrifugation was done once again at 10000 RCF at the same temperature condition for the same duration. The supernatant was collected in 15 falcon tubes and was made air-tight using paraffin. The supernatant sample was stored in deep freeze until an assay was performed (Rouf et al., 2011).

Preparation of RBC suspension

This study was conducted under the as per disciplines human ethical protocol no. KU/PHARM/HEC/16/007/01. From some students at Khulna University, blood samples were collected. RBCs were washed at 4°C temperature at 600 RCF using PBS with pH value of 7.4. Washing was done for 3 times and 2% RBC suspension was prepared. With a view to marking off the suppositional lectin activity of *I. aquatica* homogenate, the HA inhibition capability of specific sugar had been used. Seven sugars were used including Glucose (G), Galactose (Gl), Maltose (Ml), Arabinose (Ar), Ribose (R), Mannose (Mn) and GlcNAc/N-Acetyl-D-Glucosamine (Gln).

Haemagglutination assay

After the preparation of 2-fold serially diluted homogenate (PBS: supernatant=1:1), an equal volume (25uL) of PBS was mixed in a U-bottom 96-well plate. Subsequently, 50uL of 2% RBC suspension was mixed and left at room temperature. The result was recorded after one hour when the negative control was sedimented completely. The result was determined by taking the reciprocal of the highest dilution that showed haemagglutination and expressed as HA Unit (HA-U) (Rouf et al., 2011). Next, serially diluted sugar solutions (D-Glucose, Galactose, Maltose, L-Arabinose, D-Ribose, D-Mannose and N-Acetyl-D-Glucosamine each 25uL) were taken in 96-well plate as inhibition chemicals and the maximum dilution of homogenate (25uL) that possessed hemagglutinin was mixed into the U-bottom 96-well. Following that 50uL of 2% RBC suspension was added and left at room temperature for some time. Result was recorded one hour later, and complete sedimentation indicates the presence of lectin. The data were represented as images of whether lectin was present (mean complete sedimentation) or not (mean no sedimentation) without any statistical analysis.

Table 1. Selected sample with their family, distribution and collection period

Scientific name	Family	Collection date	Distribution
Spinacia oleracea	Amaranthaceae	01/02/2018	All over Bangladesh
Ipomoea aquatica	Convolvulaceae	16/07/2018	Bangladesh
Typhonium trilobatum (L.)	Araceae	15/09/2018	Indian Subcontinent
Amaranthus spinosus	Amaranthaceae	23/09/2018	All warmest continents
Alternanthera Sessilis R. Br.	Amaranthaceae	23/09/2018	Tropical and subtropical regions
Piper longum l.	Piperaceae	01/10/2018	India, Bangladesh
Amaranthus gangeticus	Amaranthaceae	01/10/2018	Bangladesh
Amaranthus viridis L	Amaranthaceae	09/10/2018	Asia, Africa, America and Europe
Eryngium foetidum	Apiaceae	09/10/2018	Grow worldwide
Cucurbita pepo	Cucurbitaceae	09/10/2018	Grow in South Asia
Bacopa monnieri	Plantaginaceae	09/10/2018	Asia, Australia
Desmodium triflorum	Leguminoseae	22/10/2018	Bangladesh
Moringa oleifera	Moringaceae	22/10/2018	Found worldwide
Enhydra fluctuans	Asteraceae	22/10/2018	Bangladesh
Coriandrum sativum L	Apiaceae	22/10/2018	Tropical and subtropical regions
Hygrophila auriculata	Acanthaceae	29/10/2018	Native to tropical Asia & Africa.
Rumex acetosa	Polygonaceae	29/10/2018	Cultivated in Bangladesh
Trianthema portulacastrum	Aizoaceae	29/10/2018	Grown in Bangladesh
Alternanthera philoxeroides	Amaranthaceae	29/10/2018	Introduced to tropical Asia

Results

The distribution and collection dates of 20 samples with their botanical profile have been summarized in Table 1. Among twenty vegetables, one was found to be active in haemagglutination titer. The titer results are represented by Figure 1 in Table 2. The plant active in HA titer was *Ipomoea aquatica* from the Convolvulaceae family. Extract of *I.*

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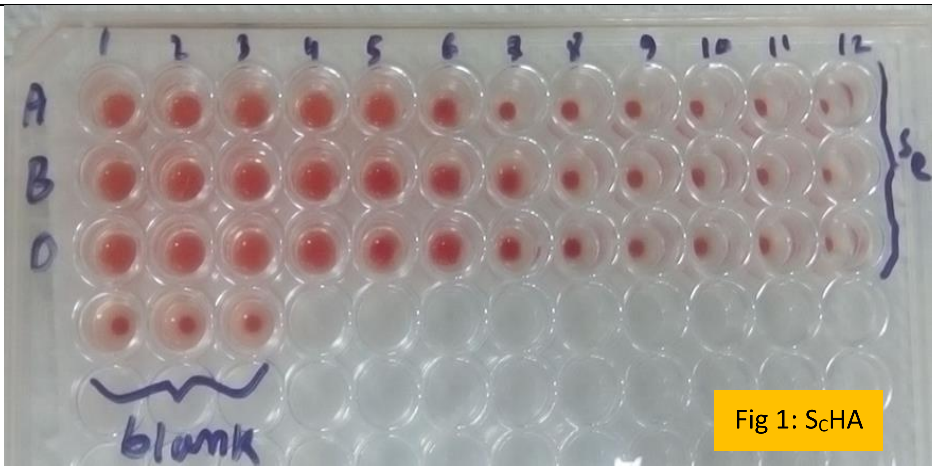
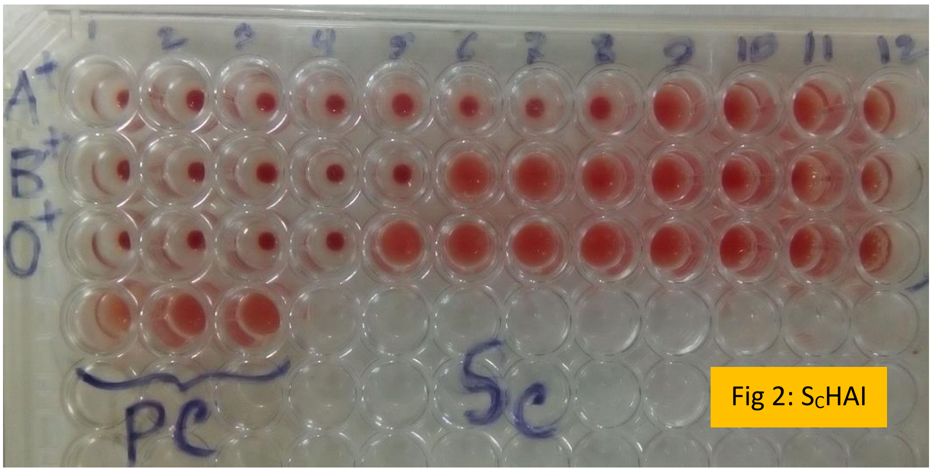
aquatica was able to agglutinate 2% RBC suspension of B (+)ve blood type with a HA titer value of 4 HA-U/25uL (Table 3). This agglutination was observed at 2nd well of 6th row of 96-well containing 1:4 dilution of homogenate (Figure 1 of Table 2).

Next, 7 sugars were tested for haemagglutination inhibition assay. Three of the tested sugars are present in human RBC as cell surface molecule, i.e. Glucose, Galactose, and N-Acetyl-D-Glucosamine (GlcNAc). As the homogenate of *I. aquatica* agglutinated the B type RBCs, B type 2% blood suspension was used for HA inhibition, and 200mM stock solution of each sugar was used after serial dilution for finding out the minimum inhibitory concentration (MIC). The HA of RBC by the homogenate was opposed by glucose (G), galactose (Gl), mannose (Mn) and GlcNAc (Gln). The MIC of glucose and mannose was equal (6.25mM). Galactose and GlcNAc had MIC of 12.5mM and 25mM, respectively. Maltose, L-Arabinose, D-Ribose did not show any inhibitory activity. These data are compiled in Table 4. A picture of HA inhibition is displayed by Figure 2 in Table 2.

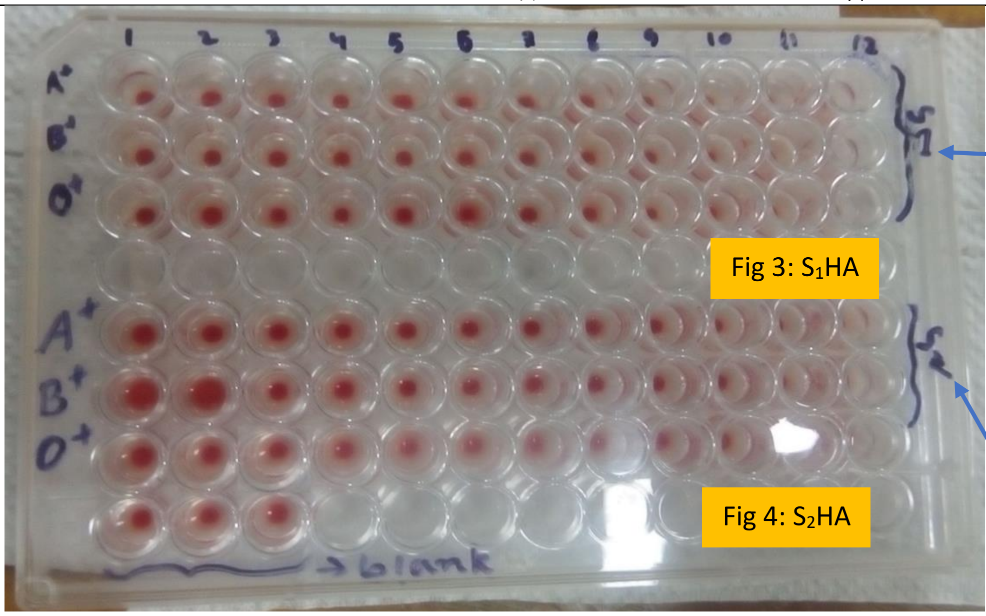
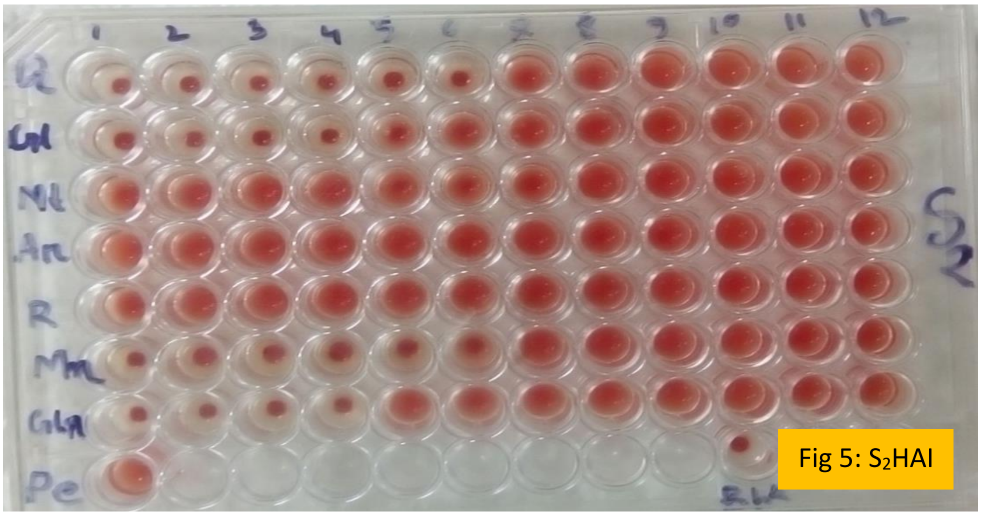
Table 2. Images HA and HA inhibition of this investigation.

Sample code	Image	Result status
	1:2 1:4 1:8 1:16 1:32 1:64 1:128 1:256 1:512 1:1024 1:2048 1:4096	
		P
		LA

a. SC=Standard control (Lens culinaris); PC=Positive Control; P=Positive; LA=Lectin active

b. SCHA=Standard control hemagglutination; SCHAI=Standard control inhibition

Table 2. Images HA and HA inhibition of this investigation (continued).

<table>
<tr><th>Sample Code</th><th>Images
1:2   1:4   1:8   1:16   1:32   1:64   1:128   1:256   1:512   1:1024   1:2048   1:4096</th><th>Result Status</th></tr>
<tr><td rowspan="2">S_1 and S_2</td><td>
</td><td>N
P</td></tr>
<tr><td>
</td><td>LA</td></tr>
</table>

S1= Spinacia oleracea; S2= Ipomoea aquatica; G=Glucose; Gl=Galactose; Ml=Maltose; Ar=Arabinose; R=Ribose; Mn=Manose; Gln=GlcNAc or N-Acetyl-D-Glucosamine; PC=Positive control; P=Positive; LA=Lectin active.; b. S1HA= Hemagglutination of Sample 1; S2HA= Hemagglutination of Sample 2; S2HAI= Hemagglutination inhibition of Sample 2; N=Negative

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Table 3.Sample found to have haemagglutination activity against human ABO type erythrocytes.

Sample Name	HA activity against PBS treated 2% RBC suspension (HA-U/25µL)[a]			Part used[b]
	A (+)ve	B(+)ve	O(+)ve	
Spinacia oleracea	N	N	N	L
Ipomoea aquatica	N	4	N	LEP
Typhonium trilobatum (L.)	N	N	N	L, T
Amaranthus spinosus	N	N	N	L
Alternanthera Sessilis R. Br.	N	N	N	L
Piper longum l.	N	N	N	L
Amaranthus gangeticus	N	N	N	L
Amaranthus viridis L	N	N	N	L
Eryngium foetidum	N	N	N	L,T
Cucurbita pepo	N	N	N	L
Bacopa monnieri	N	N	N	LEP
Desmodium triflorum	N	N	N	LEP
Moringa oleifera	N	N	N	L
Enhydra fluctuans	N	N	N	LEP
Coriandrum sativum L	N	N	N	LEP
Hygrophila auriculata	N	N	N	L,T
Rumex acetosa	N	N	N	LEP
Trianthema portulacastrum.	N	N	N	L,T
Alternanthera philoxeroides	N	N	N	LEP
Cinnamomum tamala	N	N	N	L

a. HA-U; Haemagglutination Unit, N; Negative, A(+)ve; A positive erythrocytes, B(+)ve; B positive erythrocytes, O(+)ve; O positive erythrocytes.
b. L; Leaf, LEP; Leafy Edible Part, T; Twig

Table 4. The profile of HA activity of I. aquatica homogenate against human RBCs

Type of 2% erythrocytes suspension	Sugar used for HAI assay[a]	MIC (mM)*
B positive	D-Glucose;	6.25
B positive	Galactose	12.5
B positive	Maltose	-
B positive	L-Arabinose	-
B positive	D-Ribose	-
B positive	D-Mannose	6.25
B positive	N-Acetyl-D-Glucosamine	25

a. HAI; Haemagglutination Inhibition
b. * The minimum sugar concentration able to inhibit HA activity, which was evaluated when RBCs were fully sedimented, was used to determine the minimum inhibitory concentration (MIC), mM; Millimole

Discussion

Lectins being polyvalent or univalent carbohydrate-binding oligomeric proteins are enable to interact with diverse type of cell, including normal or modified cell of human, animal as well as microorganisms, as every cell is distinct from each other by expressing different glycan arrays on their cell surface (Bies et al., 2004; Vishweswaraiah et al., 2022). In this study, human red blood cells have been used to try out the interaction with lectins using 20 vegetables and the seed of *Lens culinaris* has been used as a standard control for its potent lectin activity against all ABO type blood of humans as attested in (Heritage, 1973; Makela, 1957). Among the investigated sample, the extract of *I. aquatica* had been found to cover HA activity, and inhibited by four sugars, namely Glc, Gal, Man, and GlcNAc (Table 2), interestingly furnishing a notification of strong inhibition by Glc and Man in comparison with another two sugars. Strong inhibition of agglutination reaction by mannose reverted that D-mannose was the most powerful inhibitor of lectin due to its nifty affinity for lectin (Heritage, 1973; Stein et al., 1971). On the contrary, in this study, inhibition of HA activity by Gal is two times lower than that of the two mentioned above, while inhibition by GlcNAc is four times lower in comparison with Glc and Man. For multiple binding specificities of *I. aquatica* lectin, it's going to be done to make some hypothetical comments. Since only human RBC suspension was used in this investigation, it would not be evident that *I. aquatica* lectin has only interaction with human RBCs but may also interact with cells of other organisms. Because various cells of several microorganisms are available in the universe have one or more of above mentioned four sugar encoding cell surfaces, i.e. GlcNAc in the peptidoglycan of the gram-positive and gram-negative bacterial cell wall (Vollmer & Höltje, 2004; Weidel & Pelzer, 1964), Chitin, a polymer of GlcNAc in the fungal cell wall (Garcia-Rubio et al., 2020). The sialoglycoprotein of monkey erythrocyte membranes, glycophorin MK may provide a binding site for *I. aquatica* lectin due to being composed of NeuGc, Gal, and GalNAc (Aoki, 2017; Murayama et al., 1989). This lectin may also have interaction with erythrocytes of horse, rat, rabbit, pig, chicken and carp, as galactose is present in their erythrocytes membrane (Aoki, 2017; Fukuda et al., 1980; Krotkiewski, 1988).

Interaction between surface sialic acid of urinary bladder epithelial cells and pathogenic *E. coli* modulate the adherence independently of P and type 1 fimbria adhesion (Sakarya et al., 2003), and causes urinary tract infection (UTI) (Lewis et al., 2016). The mannose specific lectin from *I. aquatica* may have interaction with bladder epithelial cells, as mannose-containing glycoprotein receptors uroplakin 1a is present in differentiated bladder umbrella cells (Wu et al., 2009; Zhou et al., 2001), and may be used as drug career for UTI, because the fim-H of type-I pili of UPEC do bind to mannose-containing glycoprotein receptors UP1a (Zhou et al., 2001). To be a GlcNAc specific lectin, this may interfere with the synthesis and/or deposition of chitin in the fungal cell wall as like as UDA (Van Damme et al., 1998; Van Parijs et al., 1992). Mannose/glucose specific lectin are potent anti-tumor cytotoxins due to their inhibitory effect on protein synthesis (Barre et al., 2019), and might be used for developing receptor specific cytotoxin, i.e. conjugation of cytotoxic plant lectin to monoclonal anti-tumor antibody (Mody et al., 1995). According to the result of this study, the *I. aquatica* lectin has multiple specificities against carbohydrates, and after the purification of the lectin might be used for glycan research in the different fields of medical science.

Other 19 plants used in this probe did not show any HA or lectin activity against *Homo sapiens* blood. No positive HA activity of the 19 plants does not mean that these plants do not possess any lectin. It may be found to possess lectin activity or HA activity against blood of other animal or cell surface glycan of an organism (Rouf et al., 2011). Several reports has disclosed that, plant lectin can interact with surface-exposed carbohydrates of microbes and can agglutinate them (Gaidamashvili & Van Staden, 2002; Nachbar & Oppenheim, 1980; Ratanapo et al., 2001). Over and above, these plants have some reasonable pharmacological activity to be worth lectin activity accordingly (Ali et al., 2012; Bezerra et al., 2013; Bhatia & Jain, 2004; Huang et al., 2005; Hussain et al., 2011; Kolya et al., 2015; Maeda et al., 2008; Samojlik et al., 2010; Sannigrahi et al., 2010; Shokrzadeh et al., 2010). Plants with antioxidant, antimicrobial, antifungal, antibacterial, antitumor, anticancer, cytotoxic property may contain lectin, as the pronounced properties are also possessed by lectins (Dhuna et al., 2005; Hassan et al., 2015). Three plants from Convolvulaceae have already been reported to contain lectin, including *Calystegia sepium*, *Convolvulus arvensis,* and *Ipomoea batatas* (Van Parijs et al., 1992) and in this study, it has been found to have lectin in *Ipomoea aquatica* which is also a plant Convolvulaceae family.

According to this study, B-type erythrocyte is agglutinated by *I. aquatica* homogenate and show specificity towards four sugar, and further studies may reveal the lectin activity or HA activity against erythrocytes of another animal or cell of another organism. The lectin activity found from this screening investigation would be an interesting subject for purification, lectinological research as well.

Conclusion

Ipomoea aquatica has lectin protein, a polyvalent sugar binding lectin that is specific for glucose, galactose, mannose, and N-Acetyl-D-Glucosamine. Four monosaccharides' ability to neutralize haemagglutination suggests that the lectin in *I. aquatica* might be a multivalent hemagglutinin that binds carbohydrates. This is the first publication to document this. Future research can explore to evaluate these in-vitro results in-vivo and utilize this haemagglutination property of *I. aquatica* for clinical research in health care.

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Abbreviations

ABL; Agaricus bisporus lectin, AL; Amaranthin Lectins, BBB; Blood brain barrier, CBL; Chitin-binding lectins, ConA; Concanavalin A, CPL; Cucurbitaceae Phloem Lectins, Gal; Galactose, Glc; Glucose, GlcNAc; N-acetyl-D-glucosamine, HA ;Haemagglutination, HAI; Haemagglutination Inhibition, HA-U; Hemagglutination Unit, JRL; Jacalin-Related Lectins, LCA; Lens culinaris agglutinin, LL; Legume lectins, LTL; Lotus tetragonolobus Lectin, Man

;Mannose, MMBL; Monocot Mannose-Binding Lectins, NeuGc; N-glycolylneuraminic acid, PBS; Phosphate Buffer Saline, RBC; Red Blood Cell, RCA; Ricinus communis Agglutinin, RCF; Rotational centrifugal force, RIP; Ribosome-inactivating proteins, UDA; Urtica dioica agglutinin, UP1a;Uroplakin 1a, UPEC; Uro-pathogenic E. coli, UTI; Urinary Tract Infection, WGA; Wheat Germ Agglutinin

Conflict of Interest
The authors declare no conflict of interest.

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ORIGINAL ARTICLE

LIFE SCIENCE

EFFICACY OF HERBICIDES AND SHADING METHODS TO CONTROL INVASIVE *SPHAGNETICOLA TRILOBATA* (L.) PRUSKI

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Abstract

Sphagneticola trilobata (L.) Pruski is one of the most noxious invasive plant species, posing a serious threat to native biodiversity. This species has been invading large areas of Bangladesh for the last two decades. The study investigated the efficacy of herbicides and shading treatments during winter and monsoon to find an effective control method for *S. trilobata*. Both surface-inhabiting (Glyphosate) and root-inhabiting (Paraquat) herbicides were applied for six months in five different combinations (100% Glyphosate, 75% Glyphosate + 25% Paraquat, 50% Glyphosate + 50% Paraquat, 25% Glyphosate + 75% Paraquat, and 100% Paraquat) and the percentage coverage was measured for each experimental plot. Results from the study showed that all shading and chemical combinations of Glyphosate and Paraquat significantly reduced the percentage coverage of *S. trilobata* in each experimental plot ($p < 0.05$). However, the shading and Paraquat-dominated combinations reduced the coverage slowly compared to the Glyphosate-dominated ones. Among five different combinations, Paraquat-dominated herbicides were less effective in controlling the species. On the other hand, the Glyphosate-dominated combinations completely eradicated the species within a week but increased thereafter. Meanwhile, the seasonal variation was found to be highly significant ($p < 0.0001$) among treatments, and a significant reduction was observed in winter compared to the monsoon. The results of this study highlighted that the Glyphosate-dominated combinations were the fastest, while the Paraquat-dominated combinations and shading were slower control methods.

Keywords: Invasive plant, *Sphagneticola trilobata*, shading, herbicides, seasonal variations

Introduction

Sphagneticola trilobata (L.) Pruski [syn. *Wedelia trilobata* (L.) Hitchc.] is considered one of the most notorious invasive plant species on Earth. IUCN has listed it among the 100 world's worst invasive species (Lowe et al., 2000), and the Florida Exotic Plant Pest Council (FLEPPC) classified it as a category II invader (FLEPPC, 2020). It is a creeping and mat-forming perennial herb native to Central America and has already invaded the tropics and subtropics as an ornamental plant (Qin et al., 2015; Hossain & Hassan, 2005). It spreads vegetatively, forms a dense ground cover, and once established, it crowds out other species (Wagner et al., 1990; Csurhes & Edwards, 1998; Wagner & Van Driesche, 2010). It also becomes naturalized along streams, canals, borders of mangroves, and coastal strands (Thaman, 1999; Csurhes & Edwards, 1998). Apart from its invasive nature, some strong allelopathic evidence has also been found in agricultural crops like potatoes, tomatoes, and rice (Nie et al., 2004). Qin et al. (2015) reported that it prefers hot and humid environments and can occur in areas with different environmental conditions than those experienced in its native range. Due to aggressive growth habits, tolerance to environmental stresses, and the capacity to synthesize allelochemicals, *S. trilobata* can invade rapidly (Wang et al., 2012). Moreover, it can significantly reduce the germination capacity of competing plants up to ~72% especially dicots (Hernández-Aro et al., 2016).

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Through aggressive nature and allelopathy, it reduces significant amounts of food crops to inhabit biological diversity, especially for birds and insects (Linnell et al., 2009; Junhirun et al., 2012).

Globally several studies have been undertaken to control or eradicate this noxious invasive species through physical/shading treatments as an effective approach (Englberger, 2009; Junhirun et al. 2012; Qi et al. 2014; Pu et al. 2022). However, Pu et al., (2022) claimed that only uprooting is not enough to eradicate it fully as it can sprout from a single node. Chemical methods have also been tried for this species. Motooka et al. (2002) found a minimum of 2 lb/acre herbicide of dicamba, and 2,4-D was effective to kill *S. trilobata*. The plant is also sensitive to triclopyr, or Glyphosate (foliar spray) applied by the drizzle method but probably at 2 lb/acre or more (Englberger, 2009). Rolfe et al. (2019) suggested metsulfuron methyl herbicide (600g/kg) along with 10g/100L surfactant as an effective herbicide for this species in Australia. Wu and Hu (2006) suggested 1:600 picloram and clopyralid in 10 days and 1:800 fluroxypyr in 15 days as the most effective herbicides to eliminate *S. trilobata* in China. In Bangladesh, it was first reported in Gulshan, Dhaka (Hossain & Hassan 2005), where it was initially planted for ornamental purposes. In an earlier study, Rahman (2013) found this species in northern Bangladesh. The introduction of this exotic species highlights the ineffective plant quarantine system (Rahman et al., 2014). However, there is a lack of information on the spread and distribution of this invasive species in Bangladesh. So far, it is already spread to natural habitats in the Northern (Rahman, 2013), central (Mia et. al., 2020), and southwestern regions (Rahman, 2015). It has also invaded municipality areas of Dhaka and Chittagong (Ahmed et al., 2007-09). So, Bangladesh is also highly susceptible to the threat of this invasive species and poses a high risk in consideration of long-term productivity and ecological sustenance (Kanatas et al., 2020; Rasmussen, 2004).

To control this alien exotic plant, chemical application is one of the most popular and frequently used methods globally (Green, 2014), despite a few drawbacks (Weidlich et al., 2020; Randy, 1998). However, the use of extensively used chemicals can pose less harm to the ecological balance, as indicated by several studies (Chen et al., 2017; El-Metwally & El-Wakeel, 2019). In many instances, studies have shown that commonly used chemicals may have lesser effects compared to newly introduced ones, thereby avoiding the challenge of introducing new chemicals to the environment (Dayan & Duke 2006, 2014). Therefore, it is advisable to utilize commonly used herbicides for plant control where necessary, and their combinations can be tested with other environmental factors such as temperature and precipitation (Alatürk et al., 2018). Globally, Glyphosate, also known as N-(phosphonomethyl) glycine, has been extensively used as an herbicide for root inhabitation for the past 40 years due to its minimal side effects (Duke & Powles, 2008; Van Bruggen et al., 2018). On the other hand, Paraquat, a bipyridinium herbicide, has been tested as an effective contact herbicide for surface application (Bromilow, 2004). Therefore, Glyphosate (41%) and Paraquat were applied to ensure maximum effectiveness (Vicente et al., 2001) while minimizing their impact on the soil (Hawkes, 2014). In Bangladesh, Glyphosate 41% and Paraquat are also the most used chemicals for herb control (Mustari et al., 2014).

For this instance, a control strategy is much needed to develop to reduce the destructive effects of *S. trilobata* on local vegetation. But the number of studies on controlling *S. trilobata* is very minimal and most of the studies suggested removing the topsoil for full elimination (Wu et al., 2013). To eradicate this problem, posed by this invasive species, the study aims to test two herbicides (Glyphosate and Paraquat) and shading methods to reduce the coverage of *S. trilobata* in both winter and monsoon seasons.

Materials and Method

Study area

The study was conducted at Khulna University Campus, located between 22º47′57″ N to 22º48′18″ N and 89º31′38″ E to 89º32′21″ E in the southwestern part of Bangladesh (Figure 1). Several areas of this university have already been invaded by *S. trilobata*, and the experimental plots were established in those patches. This area experiences a subtropical climatic conditions with a dry winter from October to March, humid summer from March to June, and a warm monsoon from June to October. However, the maximum and minimum temperatures vary throughout the year. In December-January, the temperature falls to its lowest point at 12-15ºC, while it reaches its highest in April-June at 41-45 ºC. July is the month with the maximum amount of precipitation, with 20-25 days of precipitation (BBS, 2014).

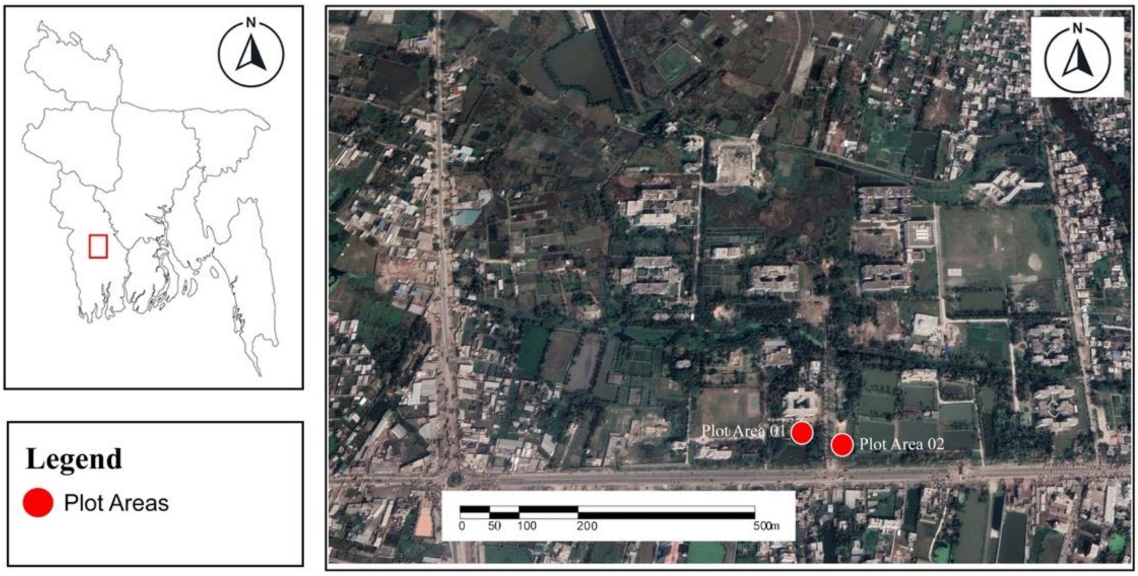

Figure 1. Study area in Khulna University, Khulna. The red dot indicates the experimental plot.

Experimental design

To apply the shading and herbicides treatments, 36 square experimental plots with dimensions of 1m × 1m were established at Khulna University Campus in Khulna, Bangladesh (Figure 1). As the vegetation of the area exhibited two distinct growing seasons, namely monsoon and winter, throughout the year, the treatments were replicated in both seasons to analyze the changes in coverage of the studied species. For the analysis of the herbicides and shading treatments, three replications were conducted in each season for all treatments. Therefore, a total of 18 sample plots (3 × 6) were studied, consisting of six different treatments (shading and five combinations of herbicides) for each season. For the shade treatment, the entire plot area was covered with an opaque PVC Vinyl sheet, and data were collected on a weekly basis for six weeks. However, for the chemical treatment, the percentage coverage was measured daily for three weeks. The observations were conducted based on the decreasing rate of coverage of the studied species. To measure the effectiveness of the herbicides, this study used the most readily available herbicides for surface application (Glyphosate 41%) and root application (Paraquat) (Figure 2). For applying the herbicides treatment, a 2% water solution of each herbicide (Glyphosate and Paraquat) were prepared and then mixed with different combinations. The applied mixing ratio of the herbicides are following: 1:0 (100% Glyphosate), 1:3 (75% Glyphosate + 25% Paraquat), 1:1 (50% Glyphosate + 50% Paraquat), 1:3 (25% Glyphosate + 75% Paraquat) and 0:1 (100% Paraquat). These treatments were replicated three times for both the monsoon season (May-June) and the winter season (December-January) to analyze the gradual decrease in cover (%) of the studied species.

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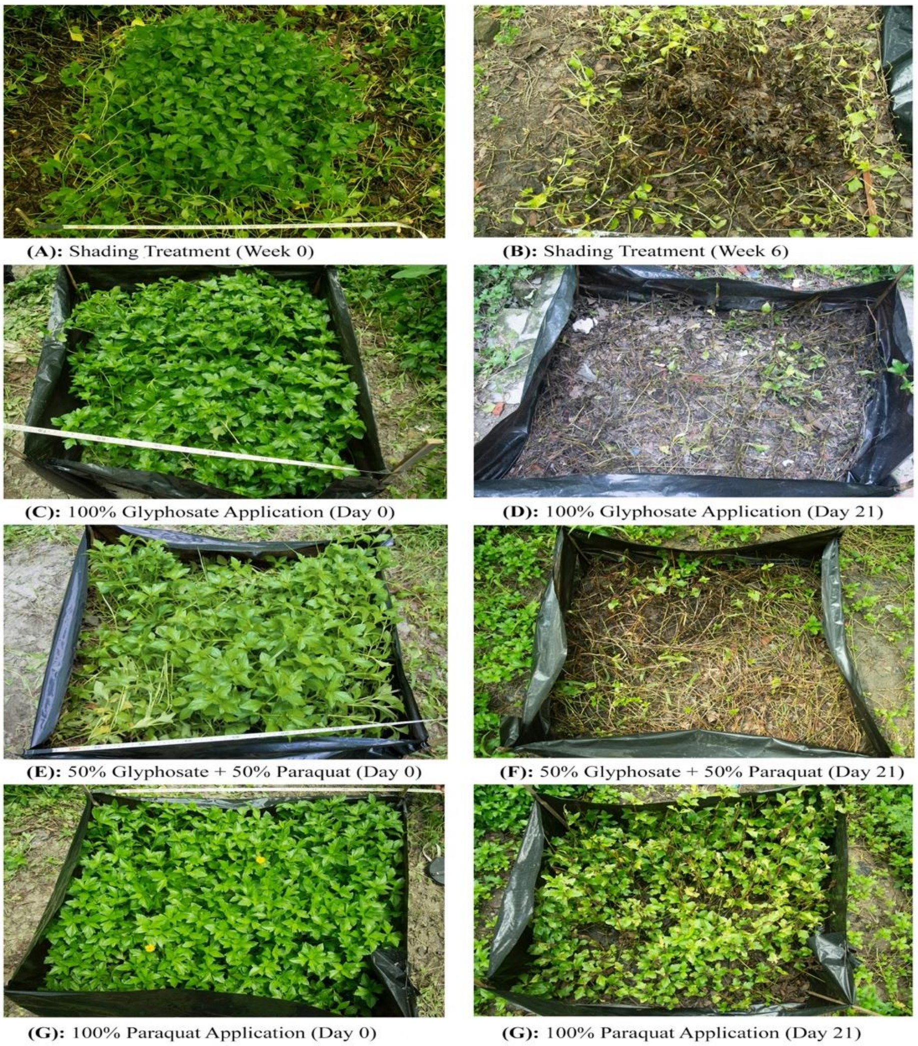

Figure 2. *S. trilobata* coverage in shading and herbicides treatment combinations.

Data Collection

The effectiveness of the shading and herbicides treatments was determined by analyzing the percentage of vacant areas, which were captured as images at specific time intervals (weekly for shading and daily for herbicides treatments). The plot areas were captured with a Nikon-D3200 camera with Nikkor 55–300 mm AF-S DX lens at a height of 1m, and calibration was maintained by placing a meter tape next to each sample plot. After capturing the images from each plot, the coverage was calculated using Image J (Version 1.6.0). To calculate the gradual decrease in coverage, the pixel error was set to less than 5%. Pixels exceeding this threshold were corrected for illumination gradients and converted to black and white (B&W) (16 bytes) using interactive threshold to mask the actual coverage (Figure 3).

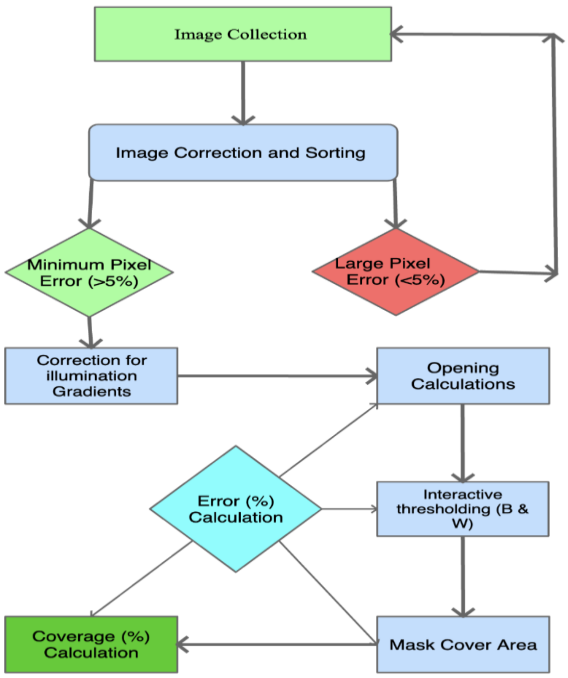

Figure 3. Flowchart showing steps involved with image analysis tool application (Image J) for the measurement of area coverage (%).

Statistical analysis

All statistical analysis and graphics were performed using R statistical software (version 4.0.4) (R Core Team, 2020). The normality of residuals and heteroscedasticity were assessed using the Shapiro-Wilk normality test from the 'R stats' base package and the studentized Breusch-Pagan (BP) test from the 'MuMIn' package (Fox & Weisberg, 2019; Bartoń, 2020). The percentage coverage data were subjected to an arcsine transformation before conducting the statistical tests, and subsequently back-transformed for graphical presentation. The cumulative coverage of each day/week and season, corresponding to a particular treatment, were analyzed using two-way/three-way analysis of variance (ANOVA) tests using with the 'car' package (Fox & Weisberg, 2019).

Results

Effect of shading on S. trilobata coverage

The shading treatment successfully decreased the coverage of *S. trilobata*. After five weeks, the percentage coverage decreased to 93% in the winter season, while in the monsoon, it was 88% (Figure 4). However, there was a slight increase again in week six. The two-way Analysis of Variance (ANOVA) test showed that both season and week had a significant impact on reducing the coverage of *S. trilobata* (Week, $F_{6, 28} = 554.41$, p <0.0001 and season, $F_{1, 28} = 47$ 31.55, p <0.0001) (Table A.1). However, there was no significant interaction between them.

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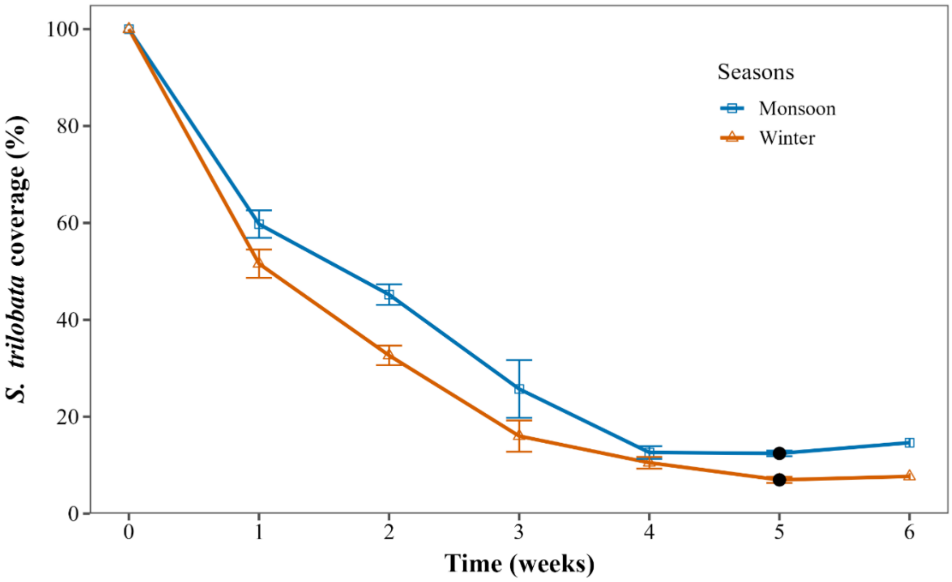

Figure 4. The percentage coverage of *S. trilobata* under shading treatment in monsoon and winter. The black dot indicates the lowest percentage coverage of *S. trilobata*.

Effect of herbicides treatment on S. trilobata Coverage

Paraquat (100%) showed minimal effect compared to the other four herbicide treatments. It only defoliated 10-13% in monsoon, while in winter, it reduced coverage up to 30-34% within 3 weeks (Figure 5E). In the case of a 1:3 solution (25% Glyphosate + 75% Paraquat), the minimum coverage (72%) was observed in the second week in the monsoon, while in winter, it took 3 weeks to reach the minimum (53%) (Figure 5D). An equal combination of glyphosate and paraquat (50% Glyphosate + 50% Paraquat) proved to be one of the most effective chemical combinations for retaining the lowest coverage. This 1:1 solution gradually reduced the leaf coverage to a minimum value of 21% in the monsoon, whereas in winter, there was a rapid decline in the coverage area, reaching 16% in the first week (Figure 5C). Among the different combinations of Glyphosate and Paraquat, a higher concentration of Glyphosate (25% Glyphosate + 75% Paraquat) accelerated the rate of declining cover within 1-2 weeks, but the yield was retained for a shorter period. For this specific treatment, the minimum coverage was recorded at 9% in the monsoon after two weeks of application. However, in winter, the decline rate was faster than in the monsoon, reaching the minimum value of 6% in the first week (Figure 5B). Among all treatments, pure Glyphosate (100%) application showed quick but less stable defoliation compared to other treatments. Pure surface application in the monsoon resulted in the maximum decrease in area coverage (2.7%) in the second week, while the minimum value in winter was recorded at 3.3% in the first week (Figure 5A).

The three-way ANOVA showed that the percentage of coverage of *S. trilobata* significantly decreased due to the application of the treatments up to twenty-one days in both seasons (days: $F_{21, 440} = 430.58$, $p < 0.0001$, 172 seasons: $F_{1, 440} = 233.78$, $p < 0.0001$ and herbicides treatment, $F_{4, 440} = 4318.54$, $p < 0.0001$) (Table A.2 & A.3). The pairwise combination of days, seasons, and treatments also resulted in a significant reduction in the coverage of the studied species ($p < 0.05$). Additionally, the interaction effect of days, seasons, and treatments was found to be significant ($p < 0.05$).

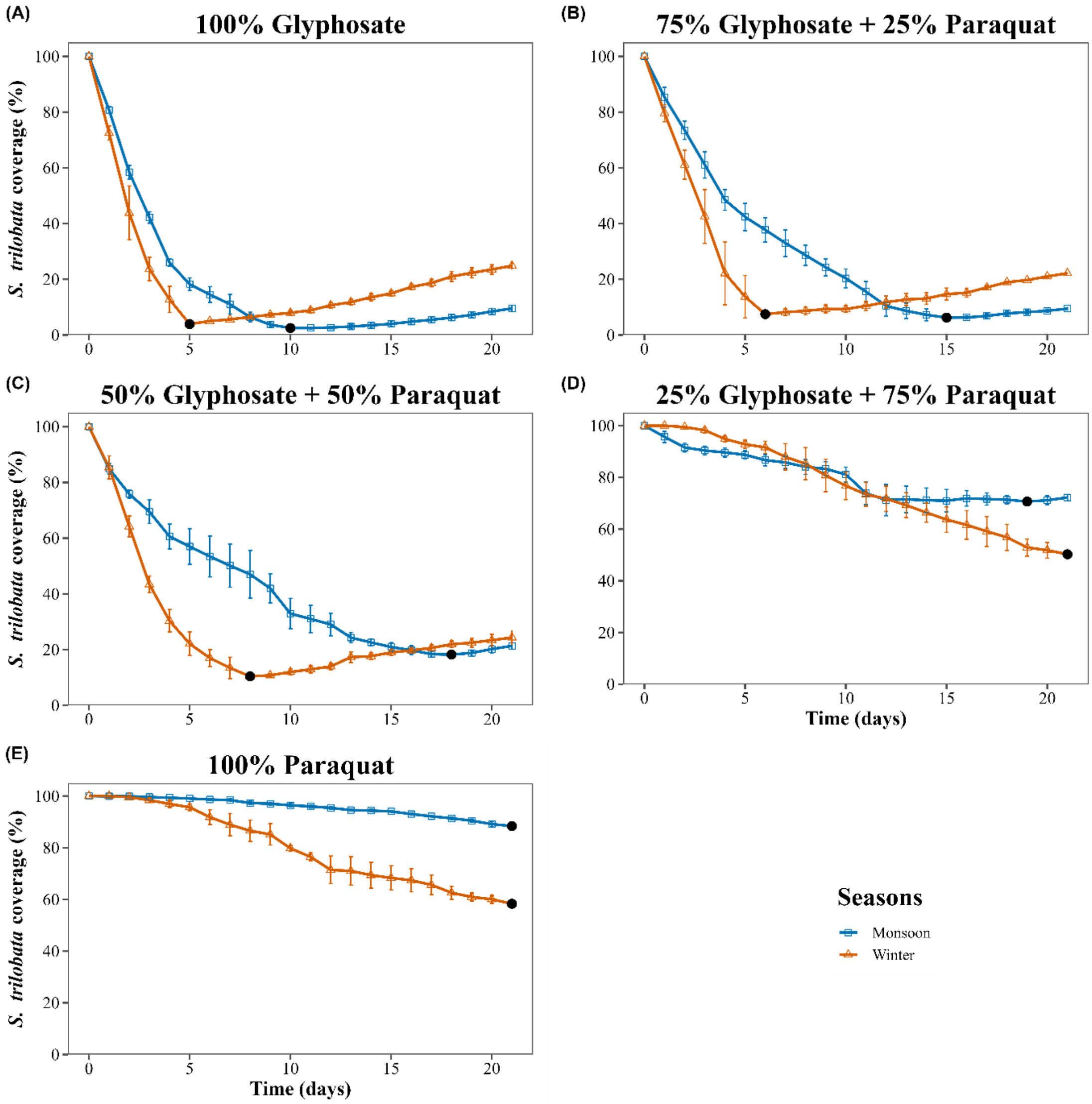

Figure 5. *S. trilobata* coverage in different combinations of herbicides treatment. The black dot indicates the lowest percentage coverage of *S. trilobata*.

Comparison among shading and herbicides treatment

The coverage of *S. trilobata* was monitored against shading treatments for six weeks and herbicides treatments for three weeks (Figure 6). The percentage coverage decreased by approximately 95% with Glyphosate dominated combination within one week in winter, but it started to increase again afterward. On the other hand, both shading and Paraquat dominated combination showed a slower decreasing rate, and neither showed any increasing trend after three weeks. The three-way ANOVA showed that the percentage of coverage of *S. trilobata* significantly decreased from the beginning of the treatments until three weeks in both seasons and across all six treatments (weeks: $F_{3, 96} = 2341.99$, $p < 0.0001$, seasons: $F_{1, 96} = 55.0$, $p < 0.0001$ and treatments, $F_{5, 96} = 533.47$, $p < 0.0001$) (Table A.3). The pairwise combination of weeks, seasons, and treatments also resulted in a significant reduction in the coverage of the studied species ($p < 0.05$). Additionally, the interaction effect of weeks, seasons, and treatments was found to be significant ($p < 0.05$).

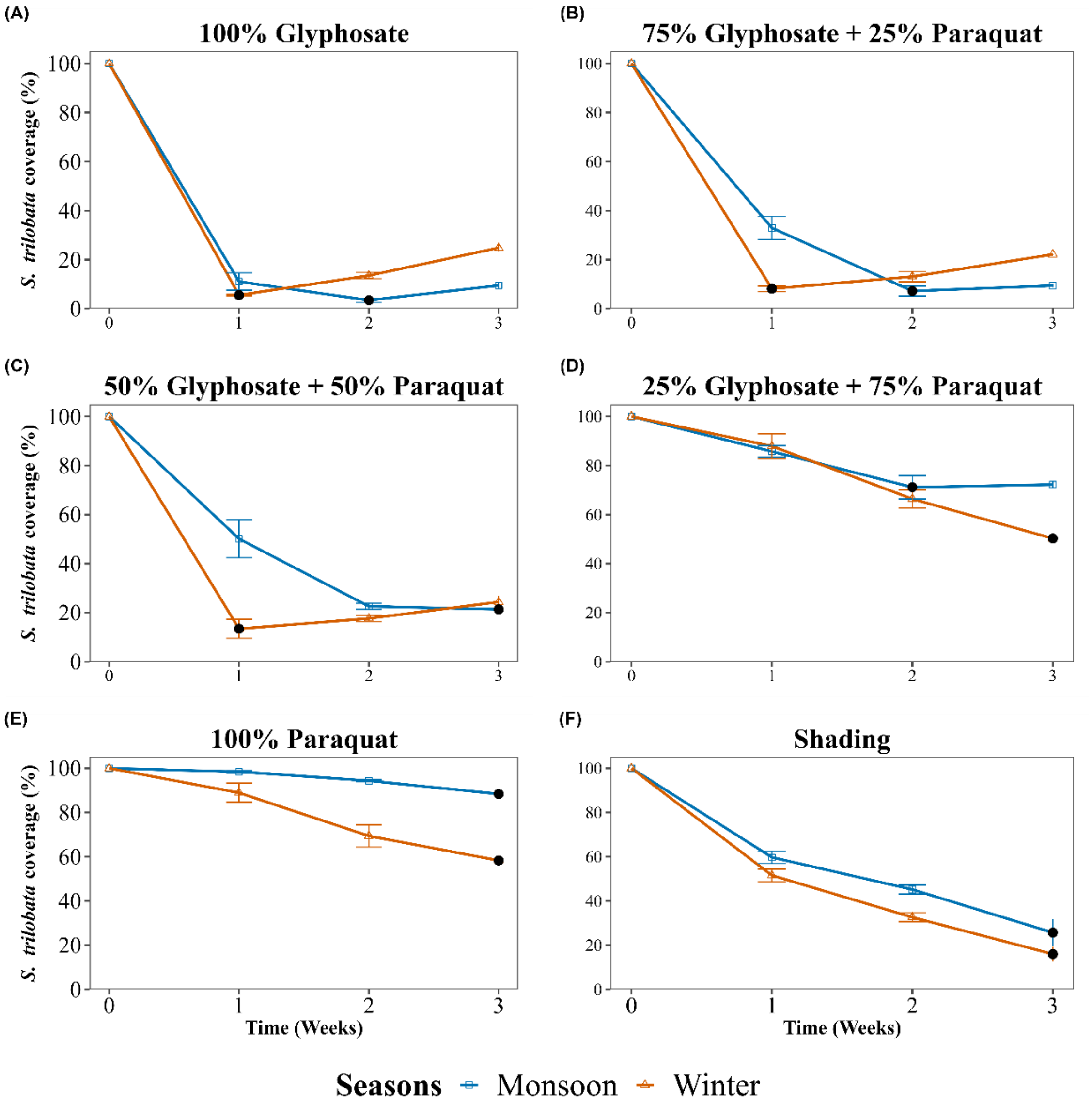

Figure 6. *S. trilobata* coverage in shading and herbicides treatment combinations. The black dot indicates the lowest percentage coverage of *S. trilobata*.

Discussion

The present study investigated the effect of shading and chemical herbicides in controlling the noxious invasive species, *S. trilobata*, in Bangladesh. Irrespective of the combinations, all six treatments successfully eradicated the coverage of the studied species. However, the shading treatments showed better results compared to Paraquat herbicides. Due to their environmental friendliness, shading methods can be a viable alternative to chemical approaches. Shading exhibited consistent and favorable reductions over time, achieving a decline of up to 21% in coverage during winter within three weeks. In addition to the growing popularity of biological control methods for invasive species (Müller-Schärer et al., 2004; De Clercq et. al., 2011), several other chemicals and shading control methods have been recommended for selected species in a controlled environment (Weidlich et al., 2020; Schooler et al., 2010). Consistent with the findings of Wu et al. (2013), our study also observed that the coverage of *S. trilobata* can be reduced up to a maximum of 97% but achieving complete (100%) elimination is challenging. The retention of that minimal leaf coverage lasts only 12-19 days (Figure 5 & 6), after which *S. trilobata* begins to regrow.

Herbicides have a significant impact on plant physiological processes, particularly in terms of restricting nutrient and water uptake from the soil, which can lead to tissue damage (Belgers et al., 2007) and the destruction of root microbe associations (Thetford & Gilliam, 1991). However, plants possess a high degree of flexibility and adaptability to cope with root stress, and alternative methods can be employed to minimize its effects (Pan, 2001). In this study, it has been observed a similar pattern of slow response for root applications (Figure 5A-5C). For example, root applications or mixtures dominated by Paraquat (100% Paraquat, 25% Glyphosate + 75% Paraquat, 50% Glyphosate + 50% Paraquat) required a longer time to decrease leaf coverage compared to Glyphosate-dominated mixtures. On the other hand, chemicals that primarily interact with the plant surface or tissues, such as Glyphosate, have a quick impact (usually within 15 days) on plant tissues (Grillo et al., 2014). Similarly, we observed a rapid response from Glyphosate-dominated applications, whereas the Glyphosate (100%) mixture required less than a week for significant effects to be observed (Figure 6F).

All treatments exhibited a significant decrease in coverage area during winter compared to the monsoon season. Overall, winter accelerated the reduction of leaf coverage for both shading and herbicides treatments. Therefore, applying control measures for this species during winter would be preferable in tropical and subtropical environments. The seasonal effects, particularly the environmental gradients, had a notable influence on the rapid decline of leaf coverage observed in this study, which aligns with findings from a previous study (Morais et al., 2021).

Among six treatments, the shading treatment and Paraquat-dominated combinations exhibited a slow reduction in the coverage area. On the other hand, the Glyphosate-dominated combinations showed the fastest decrease in leaf coverage within one week. After applying the herbicides treatments, the Glyphosate-dominated combination (100% Glyphosate and 25% Paraquat + 75% Glyphosate) yielded better results compared to the Paraquat-dominated combinations (100% Paraquat and 25% Glyphosate + 75% Paraquat), which is consistent with earlier studies (Mat et al., 2006; Patras & Artenie, 2007; Ada et al., 2012). In the case of 100% Glyphosate application, the leaf coverage decreased at the lowest value of 2.7% both in winter and monsoon. This herbicide provided rapid results due to its ability to swiftly reduce coverage. Conversely, a higher concentration of Paraquat application showed minimal effects (62% in the monsoon) on coverage and required the longest duration (over 21 days in winter) to take effect, making it less effective than the shading treatment.

Finally, for a control method to be considered viable, it is crucial to suppress plant regrowth for at least one season of the year (Keane & Crawley 2002; Mandle et al., 2011). However, the treatments applied in this study did not demonstrate sustained effects beyond 3 weeks for chemical treatments and 6 weeks for shading treatments. As a result, this study cannot recommend any treatment for long-term control of the studied species. Future studies should investigate the control measures over longer time intervals. Additionally, it is recommended to explore other potential shading methods, such as topsoil removal and controlled fire, to enhance the efficacy of shading control methods.

Conclusion

To eradicate the invasive creeping plant, *S. trilobata*, this study employed both shading and herbicide treatments to decrease the percentage of coverage in both monsoon and winter seasons. The results demonstrated that both shading and all five combinations of chemical herbicides effectively reduced the area covered by the studied species. Among the six treatments, the shading treatment and Paraquat-dominated mixtures exhibited a slower reduction in coverage. However, the shading treatment yielded faster results compared to the Paraquat-dominated combination. Additionally, all treatments showed a significant reduction in coverage during the winter season compared to the monsoon season. These findings highlighted that Glyphosate-dominated combinations offer the fastest method of reducing coverage while shading and Paraquat-dominated mixtures are comparatively slower in their effects.

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Conflict of Interest

The authors declare no conflict of interest

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Annex

Table A.1: Two-way ANOVA results for percentage coverage with shading treatments in different weeks and seasons.

Source	DF	SS	MSS	F	p
Weeks	6	7.3	2.1	554.41	<0.0001
Seasons	1	0.70	7.9	31.55	<0.0001
Weeks * Seasons	6	0.02	0.2	1.56	> 0.05
Residuals	28	35.5	0.06		

Table A.2: Three-way ANOVA results for percentage coverage with chemical treatments in different days and seasons.

Source	DF	SS	MSS	F	p
Days	21	38.82	1.85	430.58	<0.0001
Seasons	1	1.00	1.00	233.78	<0.0001
Herbicides Treatments	4	74.16	18.54	4318.54	<0.0001
Days * Seasons	21	0.83	0.04	9.19	<0.0001
Days * Herbicides Treatments	84	6.39	0.08	17.72	<0.0001
Seasons * Treatments	4	1.73	0.43	100.47	<0.0001
Days * Seasons * Herbicides Treatments	84	3.32	0.04	9.21	<0.0001
Residuals	440	1.89	0.004		

Table A.3: Three-way ANOVA results for percentage coverage with shading and herbicides in three weeks and seasons

Source	DF	SS	MSS	F	p
Weeks	3	21.79	7.26	2341.99	<0.0001
Seasons	1	0.17	0.17	55.0	<0.0001
Herbicides Treatments	5	8.27	1.65	533.47	<0.0001
Weeks * Seasons	3	0.16	0.05	17.30	<0.0001
Weeks * Herbicides Treatments	15	3.37	0.22	72.37	<0.0001
Seasons * Herbicides Treatments	5	0.31	0.06	19.89	<0.0001
Weeks * Seasons * Herbicides Treatments	15	0.56	0.04	11.88	<0.0001
Residuals	96	0.30	0.003		

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ORIGINAL ARTICLE LIFE SCIENCE

MORPHOLOGY OF *PILA GLOBOSA* (GASTROPOD MOLLUSCA: AMPULLARIIDAE) WITHIN ENVIRONMENTAL VARIATION OF SOUTH-WESTERN BANGLADESH

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Abstract

Owing to the community engagement of the gastropod collection in the south western ecosystems in Bangladesh, the gastropod molluscs are getting important attention in terms of edible and non-edible purposes while detailed morphological information about the gastropods is scarce in this area. The present research has investigated the morphological variability of the gastropod molluscs (*Pila globosa*) in the six localities of south-western coastal Bangladesh (such as, *Khulna*, *Bagerhat*, *Satkhira*, *Gopalganj*, *Pirojpur* and *Jessore*). A total of 2160 gastropod samples (*Pila globosa*) were collected from July to December monthly over the two consecutive years of 2013 and 2014. The results of the analyses revealed that the maximum monthly mean values of the dry shell mass and the dry body mass were found in November, indicating the complete growth and development of the gastropods in the coastal environment. One-way ANOVA and ANCOVA show that there is a significant morphological variability of *Pila globosa* among different localities in the south-west coastal Bangladesh, while the covariate of water salinity significantly affects the aperture length of it; the covariate of electrical conductivity of soil significantly affects both the height and aperture length; the covariate of sodium contents of the soil significantly affects the aperture length of the gastropod mollusc. The results also revealed that the morphological variability of the mollusc *P. globosa* is linked to complex ecological systems and habitat variation.

Keywords: Morphology, variability, gastropod, snails, south-west, Bangladesh

Introduction

Gastropod molluscs are particularly important communities in many coastal ecosystems. Freshwater gastropod molluscs are important bio-indicators of aquatic pollution (Dalu & Chauke, 2020) and play a vital role in refining contaminated water of the aquatic environment. Understanding the environmental factors that control the abundance and distribution of freshwater gastropod molluscs is important because the knowledge of that factors will help policymakers to manage, conserve, monitor and restore the aquatic environmental quality (Bespalaya et al., 2021). The scientific knowledge about the information on gastropod molluscs is scarce in Bangladesh; however, the species at the coast of Bangladesh have socio-ecological emphasis for the edible and non-edible (e.g., for poultry and fish meal, ornaments) purposes.

However, survival of gastropods is regulated by various physico-chemical factors that play major roles in determining the ecological traits associated with a particular species (Dunithan et al., 2012; Begum et al., 2018). The ecology of these gastropod molluscs is chiefly altered by environmental factors like physico-chemical parameters of water and habitat's substrate and even, that environmental factors determine the mollusc richness and distribution in different areas (Dillon, 2000; Garg et al., 2009; Harayashiki et al., 2020; Colvin et al., 2022; Sandip et al., 2022). For a better understanding of the benthic ecosystem and coastal environmental changes, studies on the relationship between gastropod molluscs and environmental factors in terms of their physico-chemical parameters like water and

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habitat's substrate or sediment are very important (Lorencova´ & Horsa, 2019; Ganguly et al., 2020; Colvin et al., 2022).

But, investigations on the environmental factors that determine gastropod mollusc's richness and distribution in coastal wetland systems are scarce in south-western coastal area of Bangladesh and hence, it is important to investigate the morphological variability of gastropod molluscs and the relationship of environmental factors in terms of physico-chemical conditions of water and habitat's substrate/sediment with mollusc's morphological variability in the south-western coastal area of Bangladesh. It is also imperative to understand the morphological variability of molluscs (*Pila globosa*) under different environmental conditions because they act as an excellent environmental archive for predicting past environmental conditions including climate change. The results of the research will act as the baseline data of this region to understand the present and predict the future climate change and environmental reconstruction. So, the morphological data of this research will serve as the past baseline environmental achieve, which would have an important and significant impact in the field of functional ecology and environmental reconstruction research for the coastal ecosystem management of this south-western coastal region.

Therefore, the main goal of this study was to determine the morphological variability of *Pila globosa* in relation to environmental parameters and habitat variations (water and habitat's substrate/sediment) in the six localities of south-western coastal Bangladesh (such as, *Khulna*, *Bagerhat*, *Satkhira*, *Gopalganj*, *Pirojpur* and *Jessore*). The study will allow for the proper management of ecosystems and their services in the coastal area of Bangladesh. Even, the result of the study will form the baseline data for such macro-benthic invertebrates (gastropod molluscs) in this south-western coastal Bangladesh and finally, the results of this study can be used by policymakers of Bangladesh to evaluate environmental changes.

Materials and Method

Study Area

The study area of the research lies in the six localities of the six coastal districts of the south-western Bangladesh (*Khulna*, *Satkhira*, *Bagerhat*, *Gopalganj*, *Jessore* and *Pirojpur*), which receive discharges of water and sediment from the Ganges-Brahmputra-Meghna (GBM) river system and support rich wetland biodiversity including gastropod molluscs (*Pila globosa*) in the area (Figure 1).

The topography of the study area is very flat and consists of quaternary sediments, where clay soils in the low-lying areas and soils of medium textural compositions in the highland areas are predominant (Brammer, 2014). Climatically, the study area is located in a tropical zone with a dry winter period (December to March) and moist monsoon period (June-August), receiving an average minimum rainfall of about 1800 mm/yr (Azam, 2011).

Methods

With a view to analyzing the morphological variability of gastropods, a total of 2160 gastropod (*Pila globosa*) samples were collected for a consecutive six month period from July 1 to December 30, in a monthly basis over the two consecutive years of 2013 and 2014. The total of 2160 gastropod samples generated from: 30 samples from each locality*06 months = 180 samples, after two years, 180 samples*02 years*06 localities = 2160 samples. Considering the easy accessibility and availability with abundance of gastropod molluscs, the samples were collected within the six localities from the six south-west coastal districts in Bangladesh namely, *Khulna* (*Katkata Beel* of *Uttar Bedkashi* under *Koyra Upazila*; *Melakpuraikathi* of *Godaipur* and *Chandkhali union* under *Paikgacha Upazila*), *Satkhira* (*Paromanandakathi* of *Moutala* under *Kaliganj Upazila*, *Rudrapur* of *Vurulia*, *Hasarchalk Beel* of *Patchsatabigha* of *Iswaripur* and *Munshigonj Union* of *Shyamnagar Upazila*), *Bagerhat* (*Surigati Beel* under *Chitalmari Upazila*, *Borobondher Beel*, *Chuchramari*, *Malomgacha*, *Teligati* under *Morrelganj Upazila*, *Baniakhali Beel*, *Baniakhali*, *Khontakata* under *Sarankhola Upazila*), *Gopalganj* (*Chanda Beel* under *Muksudpur Upazila*), *Jessore* (*Borenga Beel*, *Borenga*, *5 no. Mangalkot*; *Pacaroi Beel*, *Pacaroi*; *Basuntia Beel*, *Basuntia* under *Keshabpur Upazila*) and *Pirojpur* (*Dakatia Beel*, *Dakatia*, *Durgapur*; ponds of *Pirojpur municipality*; *Dakkhin Gabtola Beel*, *Dakkhin Gabtola*, *Shikdar Mollik* under *Pirojpur Sadar Upazila*).

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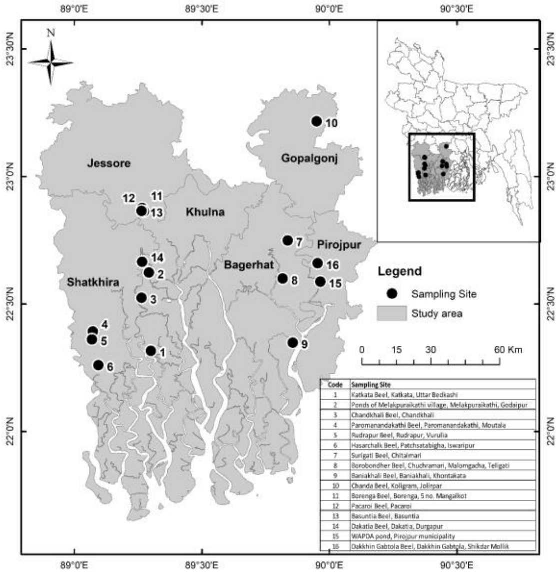

Figure 1. Sampling sites of the six localities (*Khulna*, *Satkhira*, *Jessore*, *Bagerhat*, *Pirojpur* and *Gopalganj*) in south-western Bangladesh.

The samples were collected following standard procedure using net and immediately brought to the laboratory for the analysis. The samples were preserved using 70% ethanol. The morphological parameters of the collected samples such as, height (L1), width (L2), aperture length (L3), aperture width (L4), dry shell mass, dry body mass and thickness of animals (Table 1) were determined in the laboratory by using slide-calipers and fine balance according to Begum el al. (2009).

The water samples from the habitat were collected monthly over six months from six sampling locations and the collected samples were analyzed for pH, temperature, DO (dissolved oxygen), EC (electrical conductivity), TDS (total dissolved solid) and salinity in the laboratory by following standard methods (APHA, 1995), while the soils of the *Pila* habitats were also collected from six sampling localities and analyzed for pH, EC, salinity, calcium, magnesium, phosphorous, sodium, potassium and organic carbon contents following the standard procedure as described in Ramesh and Anbu (1996).

Statistical analyses were performed to understand the spatial variability and relationships among morphological parameters, water and sediment quality parameters. The analysis of variance (ANOVA) was performed to understand the significant spatial variability of the morphological parameters of the gastropod molluscs in different parts of south-western Bangladesh, while the covariance analysis (ANCOVA) was performed to understand the significant influence of various covariates on morphological parameters in different localities. Moreover, factor analysis (FA) as a multivariate statistical tool was performed to assess the factors controlling the mollusc's variability in different localities of coastal Bangladesh.

Table 1. Measurement of individual morphological parameters.

Morphological Parameter	Definition	Figure
L1	Length-1/L1 is the height of *Pila globosa* measured from its apex to aperture in cm.	
L2	Length-2/L2 is the width of the gastropod (*Pila globosa*) in cm.	
L3	Length-3/L3 is the aperture length of the gastropod (*Pila globosa)* in cm.	
L4	Length-4/L4 is the aperture width of the gastropod (*Pila globosa*) in cm.	
Dry shell mass	After removing the soft parts of body from the gastropod shell and then the mass of the dry shell (gm) of the mollusc was measured.	
Thickness of Operculum	The measurement procedure of the thickness (cm) of the operculum with the slide calipers is shown.	
Dry body mass	After drying in oven for three days under 65-70^{0}C, the soft body dry mass (gm) was obtained.	

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Results and Discussion

Morphological Variability of the Molluscs (Pila globosa)

The mean monthly variations of the morphological parameters of the gastropod molluscs (*Pila globosa*) are presented in Figure 2 and Figure 3. Moreover, the variability of the mean values of the morphological parameters of the gastropod molluscs (*Pila globosa*) from the six districts of the south-western coastal areas of Bangladesh is presented in Figure 4.

The figure (Figure 4) shows that the maximum mean value of the morphological parameter of L1 (height) is found to be 4.57 cm at *Satkhira* and the minimum value is 4.24 cm at *Khulna*. The maximum mean value of the thickness is found to be 0.14 cm at *Gopalganj* and the minimum value is 0.12 cm at *Jessore*. The maximum mean value of the dry shell mass is found to be 8.32 gm at *Satkhira* and the minimum value is 7.38 gm at *Jessore*, whereas the maximum mean value of the dry body mass is found to be 2.80 gm at *Satkhira* and the minimum value is 2.21 gm at *Khulna*.

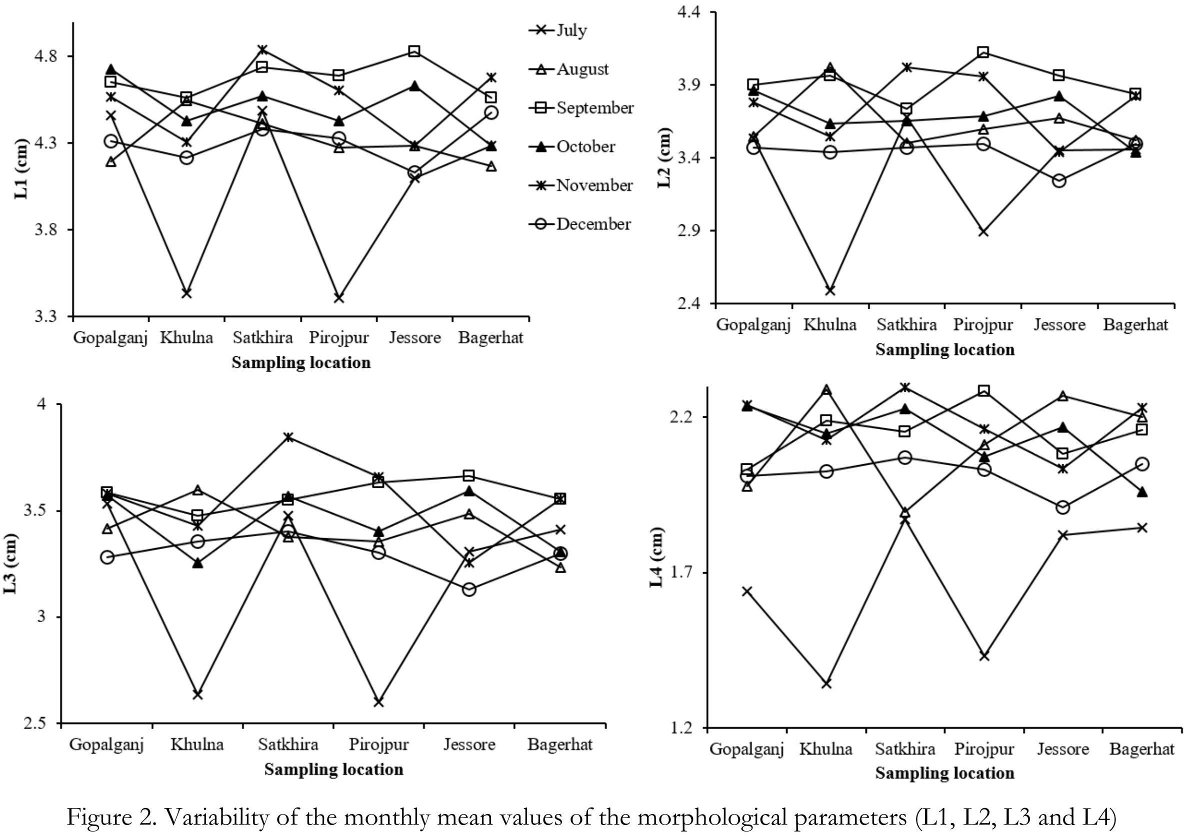

Figure 2. Variability of the monthly mean values of the morphological parameters (L1, L2, L3 and L4) of *P. globosa*.

The descriptive statistics of the morphological parameters of the gastropod molluscs for six districts show that in *Gopalganj* the dry shell mass of the gastropods varies from 2.01 to 23.65 gm with a mean of 7.87 gm and the standard deviation of 3.80. In *Khulna*, the dry shell mass varies from 1.38 to 22.70 gm with a mean of 7.39 gm and the standard deviation of 3.61. In *Satkhira*, it varies from 1.09 to 22.94 gm with a mean of 8.33 gm and the standard deviation of 4.08 and in *Pirojpur*, it varies from 1.42 to 21.93 gm with a mean of 7.51 gm and the standard deviation of 3.79.

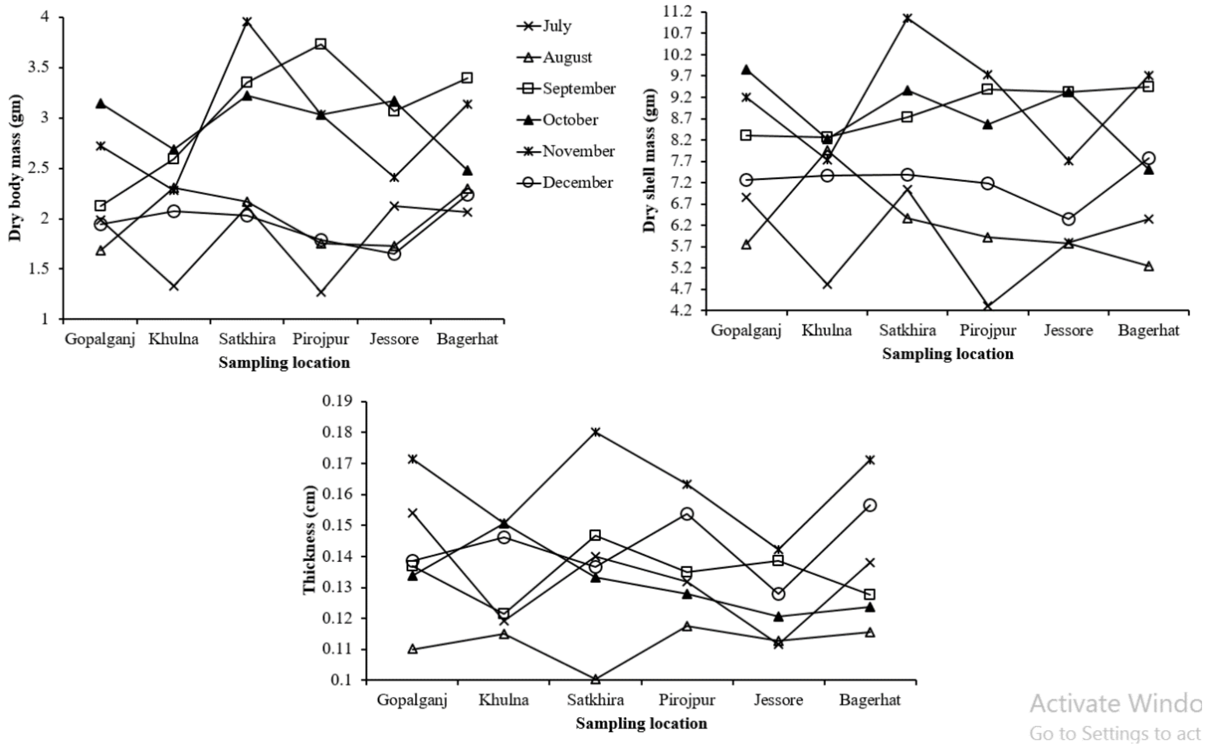

Figure 3. Variability of the monthly mean values of the morphological parameters (Dry body mass, dry shell mass and thickness) of *P. globosa*.

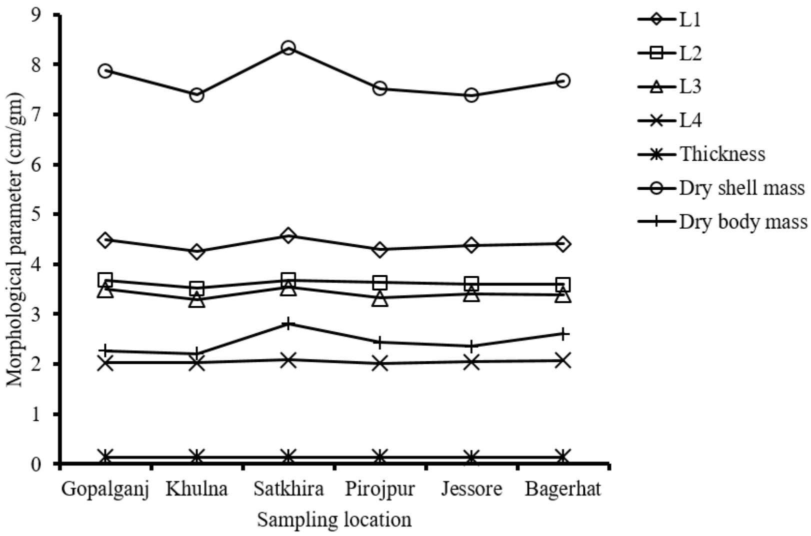

Figure 4. Variability of the mean values of the morphological parameters of *P. globosa* from six localities of the south-western coastal Bangladesh.

In *Jessore*, it varies from 1.23 to 25.62 gm with a mean of 7.38 gm and the standard deviation of 3.75 and in *Bagerhat*, it varies from 1.26 to 20.54 gm with a mean of 7.67 gm and the standard deviation of 4.08. These statistics of the dry shells mass show that *Satkhira* and *Bagerhat* have the highest variation in the dry shell mass of the gastropods. In *Gopalganj*, the dry body mass of the gastropods varies from 0.07 to 10.08 gm with a mean of 2.27 gm and a standard deviation of 1.48 and in *Khulna*, it varies from 0.24 to 6.93 gm with a mean of 2.21 gm and a standard deviation of 1.35. In *Satkhira*, the dry body mass of the gastropods varies from 0.39 to 8.30 gm with a mean of 2.81 gm and a standard deviation of 1.74 and in *Pirojpur*, it varies from 0.31 to 8.29 gm with a mean of 2.44 gm and a standard deviation of 1.53.

In *Jessore*, the dry body mass of the gastropods varies from 0.37 to 11.56 gm with a mean of 2.36 gm and a standard deviation of 1.64 and in *Bagerhat*, it varies from 0.28 to 9.78 gm with a mean of 2.60 gm and a standard deviation of 1.67. The statistics of the dry body mass show that *Satkhira* has the highest variation in the dry body mass of the gastropods among the six districts of the south-western coastal area of Bangladesh and this variability is due to the differences in their habitat composition and close connection to the sea as compared to the other districts in the south-western coastal area.

The morphological parameters also show that the maximum monthly mean value of L1 (height) is found to be 4.84 cm in November and the minimum monthly mean value is found to be 3.40 cm in July, whereas the maximum monthly mean value of thickness is found to be 0.18 cm in November and the minimum monthly mean value is found to be 0.10 cm in August. This variability is due to the occurrence of gastropod growth in November (Dunithan et al., 2012; Schöne et al., 2005; Colvin et al., 2022).

The one-way analysis of variance (ANOVA) shows that there is a significant spatial morphological variability of *P. globosa* in the morphological parameters such as heights (L1: $F_{(5, 2154)}$=10.29, P=0.000), width (L2: $F_{(5, 2154)}$=3.33, P=0.005), aperture lengths (L3: $F_{(5, 2154)}$=10.42, P=0.000), dry shell mass ($F_{(5, 2154)}$=3.16, P=0.008) and thickness of the molluscs ($F_{(5, 2154)}$=3.97, P=0.001) among different localities of the districts in the south-west coastal Bangladesh at 1% level of significance.

The analysis of covariance (ANCOVA) shows (Table 2) that the water salinity significantly affects the aperture length of the animal (L3: F=3.34, P=0.05); the electrical conductivity of soil significantly affect both the height (L1: F=3.32, P=0.05) and aperture length (L3: F=4.62, P=0.032); the sodium contents of the soil significantly affect the aperture length of the animal (L3: F=3.18, P=0.075) under different localities of the districts of the south-west coastal Bangladesh. It is found that both water salinity and electrical conductivity of the soil significantly affect the mollusc's shell morphology at 5% level while sodium contents of the soil significantly affect at 10% level. Bhuyain et al. (2020) also found similar results that the water salinity significantly affects the morphological structure of gastropod molluscs at the *Cox's Bazar* coast of Bangladesh. These results reveal that the morphological variability of the gastropod *P. globosa* is linked to complex ecological systems and habitat variation including the habitat's water and soil quality and it might be linked to many drivers such as temperature, food availability, intraspecific competition etc. (Márquez et al., 2015; Oteguia et al., 2019; Matos et al., 2020).

Factors Analysis of Environmental and Gastropod's Variability

R-mode factor analysis was performed on the mollusc morphological dataset, water quality dataset and soil quality dataset to explore the underlying factors controlling the animals morphological and environmental (soil and water) variability of the habitat from six coastal localities and the results of the factor analysis are given in Table 3. Table 3 shows only the parameters that have high factor loadings and the factors that have eigenvalues greater than 1. The results of the R-mode factor analysis show that the six factors explain more than 75% of the total variance in gastropod's morphological and environmental (soil and water) variations of the six coastal districts in south-west Bangladesh.

The variables such as soil pH, soil EC, soil salinity and sodium contents of the soil have high loadings on factor 1 (explaining 21.30% of the total variance) and factor 1 can be termed as 'soil salinity factor' of the mollusc habitats which delineates the spatial zoning of the coastal districts and thereby, the distribution of molluscs (Begum et al., 2009; 2010). The variables such as height (L1), width (L2), aperture length (L3) and dry shell mass of the gastropods have high loadings on factor 2 (explaining 17.55% of the total variance) and factor 2 can be termed as '*P. globosa* morphology' which advocates that the morphological variability of the mollusc is linked to the habitat's ecological conditions and environmental quality (Dunithan et al., 2012; Márquez et al., 2015; Begum et al., 2018). The variables such as soil calcium and soil magnesium have high loadings on factor 3 and factor 3 can be termed as 'soil alkalinity' which advocates that the soil alkaline environment can influence the distribution of molluscs (Ganguly et al., 2020). The variables such as water EC and water TDS have high loadings on factor 4 and factor 4 can be termed as 'water salinity' which advocates that the water salinity can influence the distribution of gastropods.

Table 2. ANCOVA test for the morphological parameters of *P. globosa* from six localities in the south-west coastal Bangladesh.

Covariates	Dependent variable					
	Aperture length (L3)			Height (L1)		
	Mean square value	*F*-value	*P*-value	Mean square value	*F*-value	*P*-value
Water salinity	1.03	3.34	0.05	--	--	--
Soil's electrical conductivity (EC)	1.42	4.62	0.032	1.67	3.31	0.05
Soil's sodium contents	0.98	3.17	0.07	--	--	--

Table 3. Factor analysis for understanding the environmental and morphological variability.

Parameter	Factor 1	Parameter	Factor 2	Parameter	Factor 3
Soil Na	0.946	L1	0.918	Soil Ca	-0.802
Soil pH	0.861	L2	0.910	Soil Mg	0.868
Soil salinity	0.946	L3	0.878		
Soil EC	0.952	Dry shell mass	0.915		
Initial eigenvalue	4.687	*Initial eigenvalue*	3.863	*Initial eigenvalue*	3.067
Percentage of variance	21.303	*Percentage of variance*	17.557	*Percentage of variance*	13.940
Cumulative % of variance	21.303	*Cumulative % of variance*	38.860	*Cumulative % of variance*	52.800
Parameter	Factor 4	Parameter	Factor 5	Parameter	Factor 6
Water EC	0.919	Water temperature	0.767	Water pH	0.764
Water TDS	0.923				
Initial eigenvalue	2.441	*Initial eigenvalue*	1.379	*Initial eigenvalue*	1.183
Percentage of variance	11.095	*Percentage of variance*	6.266	*Percentage of variance*	5.378
Cumulative % of variance	63.895	*Cumulative % of variance*	70.161	*Cumulative % of variance*	75.539

The variable such as water temperature has high loadings on factor 5 and factor 5 can be termed as 'water physical quality' which advocates that the physical quality of water can influence the distribution of gastropods (Dunithan et al., 2012). The variable such as water pH has high loadings on factor 6 and factor 6 can be termed as 'water chemical quality' which advocates that the chemical quality of water can influence the distribution of gastropods.

Conclusion

Freshwater gastropods are important environmental archives and play a vital role in maintaining ecological balance in the complex south-west coastal system of Bangladesh. The analyses of gastropods (*P. globosa*) from the six localities of the six coastal districts of south-west coastal Bangladesh revealed significant morphological variability among the localities and such morphological variability was largely influenced by environmental and habitat parameters and other ecological-ecosystem factors. However, more local data on the gastropod molluscs (*P. globosa*) over long period of time is required to acquire a detailed picture of the morphology and driving forces. This will enable researchers to calibrate the model animal so that this could act in climate reconstruction research and sustainable management of the complex coastal ecosystem.

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Conflicts of Interest
The authors declare no conflict of interest.

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ORIGINAL ARTICLE MANAGEMENT & BUSINESS

A VALUE CHAIN ANALYSIS OF AGROFORESTRY PRODUCTS IN THE SOUTH-WESTERN REGION OF BANGLADESH

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Abstract
This paper explores the market linkages in a typical agroforestry value chain in Bangladesh, particularly the participation of the micro and subsistence level farming and household-community units in this chain. The study area is *Dumuria* Upazila which is a 30 square km land area in the outskirt of Khulna, Bangladesh's third-largest city which is the located in the southwestern part of the country. Agro-products produced in the *Dumuria* Upazila and subsequently marketed in the local communities of *Dumuria* Bazar and *Gollamari* Bazar which are peri-urban locations of Khulna city. The particular objectives of this study were to assess agro-products value chains within the region and observing relationship of various intermediaries in the value chain, and to explore the impact of agroforestry practices on the socioeconomic condition of the local population. A semi-structured questionnaire was implemented to conduct the evaluation and 30 intermediaries were included for convenience in order to trace the network of market connection and identify persistent issues with the sale of agro-products in the study area. Explored network elements of the value chain have revealed that both the marketing of agroforestry crops and timber, include the intermediaries that have contributed to different forms of value-addition to the original product and produced higher gains for the participants in the value chain. Farmers at the item's place of origin complained about price discrimination, but it was discovered that end-market middlemen absorbed the lion's share of the total gain generated by the value chain. Findings of this study contributes in generating understanding the process of value creation, power structure, and gain sharing in the localized natural resources-based value chains.

Keywords: Value nodes, market linkages, intermediaries, value addition, gain sharing

Introduction

Bangladesh is an independent nation with an area of 148,460 sq. km. Approximately 140 million people are living here, and 65% of this population resides in the rural areas, who's major earnings come from the agriculture (World Bank 2016; Singha et al., 2019). The agriculture sector has long been quite influential in Bangladesh. This sector plays a crucial role in Bangladesh's economic growth. It is the most substantial sector that not only contributes to the GDP of the country but also employs a large number of labor force. In the success of this sector has a significant effect on macro-economic situation such as job creation, poverty alleviation, food security and nutritional attainment etc. Additionally, maintaining a sufficient amount of forest cover on earth is crucial for human civilization to survive (Jahan & Rahman, 2012; Islam et al., 2018). The forests of Bangladesh harbor an enormous

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wealth of natural resources where value chain plays a significant role in boosting the rate of economic development (Huda et al., 2012). However, the marketing of agro-products is vital as small-scale farmers' economies depend heavily on the sale of agricultural and forestry resources since they have traditionally relied on gathering domestically manufactured and consumed goods for their nutrition and other requirements (UNDP 2012). The existing agro-marketing system is largely dominated by numerous players in the value chain and there has been extremely weak post-harvest management. There are primary rural markets, assembly rural markets, secondary rural markets, suburban markets, and retail markets. Rural primary markets are spread throughout the country and usually is the first component in the market system for the farmers.

At the same time, these products are stimulating economic growth by contributing to the GDP, around 21.1% of which come from agriculture. Agriculture generates 45% of the country's total employment opportunity (Raihan & Ahmed, 2008; Foysal et al., 2013). However, value chain analysis specifically identifies all of the steps that take a fundamental commodity from its manufacturing in the field to its final use (Kaplinsky & Morris, 2000). Value of an item is constantly added in every level of the supply chain as a product travel from the manufacturer to the consumer through a number of modifications, transformations and transaction along a chain of related processes (Kirimi et al., 2014). Supply chain network eventually connect all the agricultural and small-scale forestry products from production to distribution. Moreover, the chain's actor's activities have been influenced by the product pathways, along with the relationship between the chain actors (Stoian et al., 2012). Additionally, it highlights the accomplishments of each link in the network (Islam et al., 2013). It is necessary for Bangladesh to recognize the challenges related to agro production and trade, since the value chain of agro-forestry in most Asian countries, including Bangladesh, is very erratic. Furthermore, it is claimed that farmers and traders do not earn anticipated profits from their investment because of different challenges. Moreover, owing to the impact of multiple influences, challenges vary from one farmer to another.

Small-scale farming predominates in Bangladeshi agribusiness, and the regional routes for distributing product-based local trade are highly unstable and sophisticated (Ali & Islam, 2013). Smallholders are becoming more enthusiastic in agroforestry practices today in order to generate more integrated, varied, and lucrative goods. It is one of the most productive, and so far, the most successful systems to increase forest area as well as the countries' land production (Leakey, 1996). Nevertheless, it enhances the socioeconomic circumstances of farmers by boosting productivity, income and crop security through balanced soil utilization and fertility preservation (Sharmin & Rabbi, 2016; Chakraborty et al., 2015; Scoones, 1998).

Agroforestry strategies are becoming more popular in Bangladesh given the prices for firewood in marketplaces (Islam & Noriko, 2012; Islam et al., 2012). Agroforestry practices in the south western part of Bangladesh have been running successfully as the Bangladesh Forest Department (FD) has benefited economically significantly because these programs are viewed as having more economic and environmental significance (Safa, 2004; Muhammed et al., 2008; Islam & Noriko, 2012). Similarly, agrisilviculture and aquasilviculture are the most prioritized agroforestry land-use practice in this region due to its geographical location, soil type, land availability, innovative farmers, cropland elevation and climatic condition. According to the studies done in the southern Bangladesh, agroforestry not only enhances farmers' socioeconomic standing and means of subsistence (Chakraborty et al., 2015; Rahman et al., 2012); but also guarantees the provision of environmental services even in deteriorated habitats like sandbars (Ibrahim et al., 2011).

Agroforestry development in Bangladesh's south-western region has increased recently, and farmers, middlemen, and consumers are all impacted by value added products in marketing channels, understanding the value chain is crucial. Due to the dearth of empirical evidence in Bangladesh on the supply or value chain strategy of agroforestry goods, this paper pioneers the assessment of the value chain of agroforestry products (Matin et al., 2008). On the contrary, it is crucial for policymakers in Bangladesh and other tropical and subtropical regions around the world to have knowledge on agroforestry from the south-western section of the country. Therefore, the objectives of this study are to assess different value chains of agroforestry products and observing the roles of the various intermediaries within it, and also to explore the impact of agroforestry practice on the socio-economic condition of the local people of the south-western part of Bangladesh.

Literature Review

Value chain conceptualization

A value chain is the total interdependent and coordinated string of activities including the phases from conceptualization of a product or service to distribution to consumption at the end and after use. This range of activities include different intermediate phases through which input-output transformation and delivery is performed at different levels, complete the desired lifecycle of the product or service (required to get a good or service for completing the production, conversion, and distribution processes, as well as the disposal phase after usage before it reaches its intended consumers (Kaplinsky, 2004; Collier et al., 2017). Value chain is typically understood by the relation among actors, activities, processes, markets, and their contributions toward the completion of the life cycle of a product or service. However, in the value chain, actors are distributed at several activity nodes. In a typical value chain, a set of actors who are business level actors, directly contribute in value generation and value aggregation in their respective nodes which are transferred to the subsequent activity node through prevailing norms of transactions and markets. While a set of actors don't contribute to value generation or value aggregation in any particular nodal level; they are institutional actors who create a facilitating or hindering context for the performance of at particular node in the value chain and transaction involving that particular node. The business level actors and institutional actors play by their own rules and norms of activities and transactions. There lies the disparity of economic and political power among the value chain's stakeholders (Mishra & Dey, 2018). Such asymmetry generates form the level of criticality of the actors' position and activities in the value chain, uniqueness of the knowledge, knowhow and resources in their possession, and the level of capability of performing the concerned activities (Kano et al., 2020). Level of asymmetry in resources and capability concentration among the actors in the value chain determine the difference of economic and social benefit for the value chain's participants (Ponte & Gibon, 2005; Fernandez, 2015).

Value chain has multiple spatial embeddedness due to geographic dispersion of the activities in the value chain (Barrientos et al., 2015). Geographically dispersedly distributed nature of the activities within the value chain has made it possible to correlate level of value chain participation of the regions with their level of economic and social development (Gereffi & Lee, 2016). Value chain analysis includes exploration of structures, activities, actors, norms and rules of transaction, governance framework, geographic embeddedness, level of participation and contribution of the actors and regions, and economic and social outputs and spillover incurred to actors, communities and regions (Gereffi & Fernandez-Stark, 2016; Bair, 2008).

Agroforestry value chain

In the agroforestry value chain, products are marketed from actor to actor till the point of consumption via the "long value chain," which completely incorporates the value chains of several actors (Nagurney, 2006). In basic words, the selling actor internalizes economic value as things are sold (profit), reflecting market, supply, and demand variables. However, some values—known as externalities—are not always internalized. They may be harmful (pollution) or beneficial (carbon capture). The advantages or costs associated with creating positive or negative externalities are not economically transferred or appreciated along the value chain. As a result, some procedures and activities provide value that is not represented by a monetary output, especially if they are environmentally or environmentally conscious procedures (Power, 2010).

In an agroforestry value chain, a farm can raise its profit margins by minimizing the use of inputs like herbicides and pesticides and replacing them with lower-cost inputs. (Garrett et al., 2017). Also, a farm may boost the price of its outputs and set them apart from rival goods by using more environmentally friendly techniques that would improve the quality of its outputs.

This independent subject focuses on the integration of agroforestry system in the extensive value chain, where the interactions between the farming system's upstream (such as for agricultural inputs) and downstream players directly influence the value generated at the farm level (e.g., buyers of agroforestry outputs). For instance, in order to compete in globalized markets, farmers involved in lengthy supply chains must focus and specialize in production (Moraine et al., 2014). Agroforestry farms that are more diverse and utilize fewer external inputs also engage in less market participation, which means they might possibly make up for lost economies of scale through economies of scope. Necessary infrastructure and distance may prevent some territorial agroforestry systems from being integrated, and even territorial integration may present additional challenges in the form of increased management and organization requirements as well as increased transportation and logistical costs (Garrett et al., 2017; Moraine et al., 2014). There may be some stress relief if the extensive value chain and supply chain that connect input suppliers and output consumers are shortened. Greater integration between farmers may lead to Coasean agreements that increase the value produced within agroforestry boundaries, hence decreasing logistical expenses (Havet et al., 2014; Röhrig et al., 2020). In addition, direct selling, voluntary price signaling, and on-site processing may increase the perceived value of goods and bring farmers in agroforestry closer to their intended consumers, thereby reducing the amount of value transferred to intermediary actors in the value chain and allowing farmers to capture more value-added (Alam et al., 2014; Röhrig et al., 2020). For instance, once farmers are able to communicate with customers directly or through local sales channels about their products and product features, buyers are more sensitive to ecosystem services in product value (Lovell et al., 2010; Röhrig et al., 2020).

Some of the countries impose specialized system to monitor overall agroforestry value chain system. The Mexican agroforestry value strategy talked about how digital tools and technology (like drones) can be used in agroforestry and how the government can help this industry use these tools more widely. Chavan et al. (2015) took a critical look at India's agroforestry chain and listed a number of problems that could stop it from being put into place. Burgess et al. (2015) four directions for agroforestry value chain include changing the EU's common agriculture policy (CAP) to better support agroforestry farms and systems.

Value sharing process in the value chain framework

The value portion takes into account the economic activities (income, job creation, and property) of intermediate vendors and services and support (equipment, logistics, services) as well as base providers (infrastructure, capital, development of human resources, governance system, digital innovations, information and communication are required in rural areas (Wong et al., 2013). Wong (ibid.) combines value chain and cluster based agricultural development under a single strategic framework agricultural value chain plus plus strategy which describes how value builds up and shared in different functional tiers or phases of the agricultural value chain. The value chain's upstream (development and research, high-value cultivars, farming practices), midstream (processes, high-value end uses), and downstream (traceability, marketing, targeted consumers) value activities are all actively promoted (Wong et al., 2013).

The framework first plus explains the production segment of the goods. In the second phase mechanization, financing, and agro-support services will raise productivity as a result of this, and the second bonus (value addition) is anticipated to come from broader and deepened economic roles in various crucial sectors of the value chain.

The framework also explains the increasing specialization and agglomeration within a region would result from coordination and value chain integration, which might boost their product portfolio and market reach (Dhital, 2004; Ponte & Sturgeon, 2014). Second, as middle-class customers proliferate in emerging southern regions, there is an increased desire for a variety of items that are secure and of great quality. Finally, the creation of a value chain process provides pro-poor advantages since it would give low-income inhabitants of rural regions work and incomes (Dhital, 2004). Commercial partners' involvement in the value chain process should lead to cost reduction and successful business performance since it clarifies the cost structure and increases the company's competitiveness by lowering expenses. This method's goal is to lower expenses associated with both internal operations and suppliers by providing them with contractual arrangements that will increase profits (Röhrig et al., 2020).

Value chain process helps to coordinate the actions of the many players in the agricultural value chain, which generates cash, opens up employment options, and progressively reduces poverty among disadvantaged small - scale farmers (Bair, 2008; Asogwa & Okwoche, 2012). Since the majority of agroforestry activities occur in the periphery, the link of value chain and local economic development significantly contribute to the creation of jobs, the generation of income, and the reduction of poverty, which are the primary drivers of local economic development (UNIDO, 2011).

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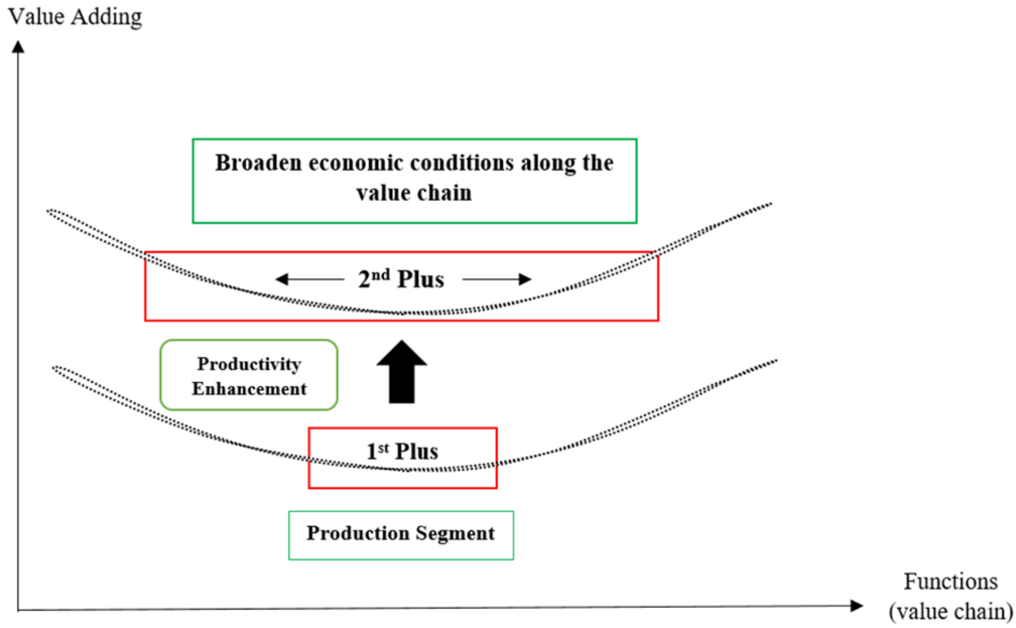

Figure 1. Value chain focused integrative agricultural development – Plus Plus Strategy
Source: Adapted version from Wong (2013)

Value sharing through value chain nodes and local economic development

Value sharing and local economic development initiatives can complement one another. Both approaches focus on the "how to" of private sector growth and may be built such that the underprivileged share in the rewards that follow. By studying it and developing interventions to get around bottlenecks and limits in the chain, value chain aims to improve how well the marketing system functions (Agbevade, 2018). Studies on local economic growth emphasized the techniques, institutional and regulatory frameworks, players, and positive results (Phelps et al., 2011). According to Pike et al. (2007) the idea of local economic growth is difficult and debatable, hence there are many different meanings.

Local economic development is founded on values and objectives that communities intentionally choose to implement in order to have an impact on their local economy and raise their standard of living. The World Bank defines it as a process by which public, private, and non-governmental sector partners collaborate to improve conditions for economic development and job creation (World Bank, 2003). Local economic development is a collaborative process that fosters cooperation agreements between the primary business and government players of a specific region. Using available resources and competitive advantage, it enables the joint formulation and implementation of a shared development plan with the ultimate objective of providing decent jobs and enhancing economy (Sarker & Ghosh, 2010). The decrease of poverty, the creation of new jobs, and the stimulation of the local economy are some of the effects of local economic development that make it possible for local economies to remain economically sustainable.

Local economic development techniques pinpoint a region's economic potential and enable local firms to cooperate with one another to boost the local economy and create jobs. Combining the methods can help to overcome any potential drawbacks of using each method alone (Saarelainen & Sievers, 2011). Due to their fundamental nature, value chain approaches transcend regional borders and are not exclusive to any one area. Unfortunately, value chain practitioners may not always pay sufficient attention to local factors such as cultural norms, regional red tape, and infrastructure development constraints. Hence, unfavorable local conditions or a misunderstanding of local conditions may provide obstacles to value chain interventions. Moreover, the crosssectoral aspect of value chain growth is strengthened by the connection between local governance, and development planning. In conclusion, a local economic development strategy can assist prevent some of the drawbacks of value chain growth by providing a greater grasp of local circumstances. In order for items to reach the end customer, collaboration between players is a key component of value chain growth. As a consequence of this, it is necessary for the many players to work together effectively, communicate effectively, and be responsive. Local economic development strategies that emphasize participation and social engagement can improve the necessary conversation among the stakeholders. Hence, local economic growth improves information flow along the value chain, making it more efficient and inclusive. Another way to assist local innovations that can increase the effectiveness of value chain growth is through local economic development (Saarelainen & Sievers, 2011).

Local economic development initiatives that emphasize involvement and communication might improve value chain growth; effective intervention does not always rely just on participation. Local economic development professionals could overlook the significance of value chain participants beyond the local area (Kistruck et al., 2013). However, a desired transformation in a value chain to expand or enhance production operations and provide social benefits such as poverty reduction, income generation, economic growth, environmental performance, gender equity, and other development (UNIDO, 2011). This concept centered in enhancing the entire value chain procedure for the betterment of society as a whole.

Materials and Methods

Study area profile

The study was performed at four unions of *Dumuria* Upazila under Khulna district of Bangladesh (Figure 2). The researchers made an effort to obtain accurate data by an exploratory survey to explore the demographic profile of the respondents including farmer's annual income, socio-economic benefits of agroforestry, and value chain for farm products manufactured from agroforestry. On the other side, this study also covered two commercial bazars namely *Dumuria* Bazar and *Gollamari* Bazar which have been selected from Khulna district in order to gather data for selecting intermediaries including *phoria* (middleman), *bepary* (trader), *paiker* (wholesaler), and retailer. Table 1 highlights the key components of the research area.

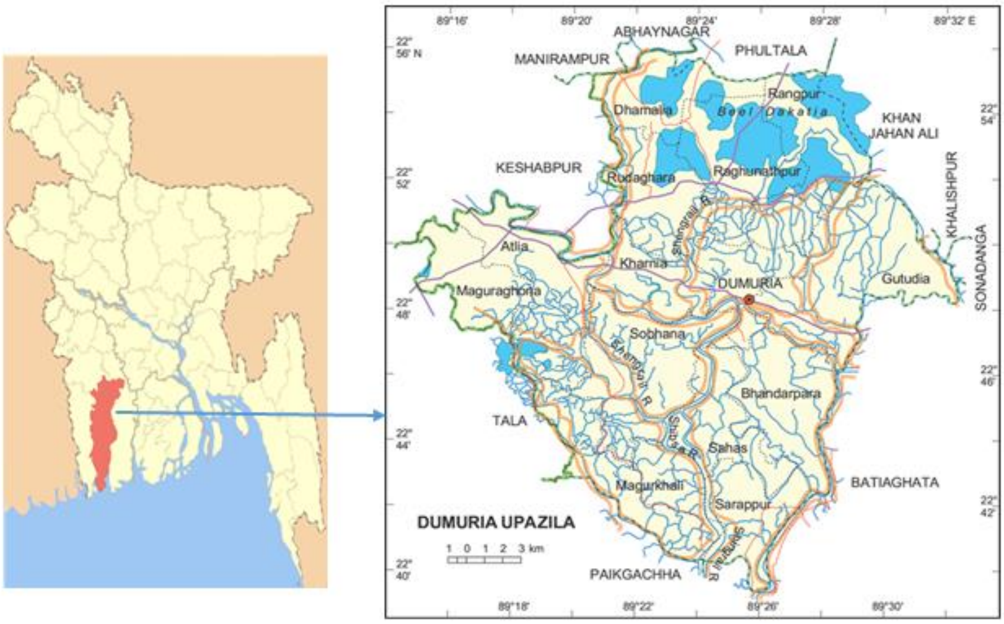

Figure 2. Geographical location of the study area

Table 1. An overview of the study area

Items	Description
Location	*Dumuria* is an Upazila of Khulna District in Khulna Division with 230 villages. It has 46,251 households and a total area of 454.23 sq. km.
GPS location	It lies between latitudes of 22°39' and 22°56' north and longitudes of 89°15' and 89°32' east.
Population	256,503 (Density: 560/km^2); males constitute 53% of the population while females do 48%.
Number of villages	230
Number of households	46,251
Literacy	It has an average literacy rate of 36.1% (7+ years) where males constitute 45.4%, and female 26.5% compared to the national average of 32.4%.
Land use	Total cultivable land is 31,340 hectares, fallow land 3,240 hectares; single crop 36.5%, double crop 33.8%, treble crop 29.7%. Main crops are paddy, jute and vegetables. Main export products are paddy, rice, betel nut, molasses, prawn, mango, jackfruit, vegetables.
Land control	20% of peasants lack land, 28% have small plots, 32% have middle-sized plots, and 0.8% are wealthy; the average cultivable plot is 0.12 hectares.
Main occupations	Agriculture 46.29%, agricultural laborer 16.8%, wage laborer 4.09%, commerce 12.9%, industry 2.01%, transport 3.24%, service 4.66% and others 10.1%

Source: Authors' compilation based on a filed survey, 2019

Season of production and crop preferences

In Bangladesh, there are typically three harvesting periods. They are Rabi, Kharif-I, and Kharif-II. The first Kharif runs from March to June, the second Kharif runs from July to October, and the final Kharif runs from November to February. Since these are the key products in the study region, vegetables including potatoes, chilis, brinjal, and cauliflower have been chosen as well as the Rabi season for the study.

Sampling frame and sample

The basic data used in the study was physically gathered in the field during November to February of 2019. Data gathering for the investigation used a multistage sampling strategy. *Dumuria* Upazila under Khulna district was selected as the primary sampling unit. Out of 14 unions in *Dumuria* Upazila, 4 unions namely *Atlia*, *Maguraghuna*, *Dumuria*, *Khornia* were purposively selected as the secondary sampling units. Two villages from each union in total 8 villages namely *Maltia, Chucknagar, Bataga, Hogladanga, Khoria, Mirjapur, Baundia, Bhadradia* were chosen randomly as third sampling units. There were around 150 farmers producing crops in the study region. About 70 people were working to provide for their families on a subsistence wages. Contrary, roughly 80 farmers were involved in commercial farming. Farmers engaged in commercial farming in the study area have been regarded as the study's population. A total of 80 farmers were selected purposively from 8 villages to represent the sample.

A detailed interview schedule was then conducted to assess age, educational status, family income, savings and agroforestry status of the study area (Table, 2). On the other side, 30 intermediaries including *phoria* (middleman), *bepary* (trader), *paiker* (wholesaler), and retailer have been chosen from *Dumuria* Bazar and *Gollamari* Bazar using a random sampling method. A collection of survey questions was employed to gather pertinent data from the participants.

Data collection and analysis

Interviews were used to gather data. Face-to-face interactions were used to complete the interviews. In order to get an appropriate response to the queries and assertions, proper connection has to be formed with them. Whenever a responder had a problem comprehending a question, it was addressed and elaborated. The study's goals were coded, assembled, tallied, and evaluated using the information gathered from all of the interview sessions. Internationally recognized standards were applied to local entities. Using appropriate grading, qualitative data were transformed into quantitative data. Wherever feasible, descriptive analysis methods including range, number, percentage, mean, standard deviation, and rank order were used. In agroforestry, value chain includes some other intermediaries, such as auctioneers, local traders, local saw-mills, brickfields and wholesalers. The respondents mostly farmers and a total 30 intermediates who were purchasing and selling agroforestry items were randomly chosen from the market area and from the side of the street as stated in the previous section. The final stage of intermediaries was where this sampling strategy was still in progress.

Findings

Demographic profile of the principal actors in the value chain

In this study, the male and female age distribution in all ages were almost the same and ranged from 21 to 60 years mentioned in Table 2. The study area's responding farmers were discovered to be on average roughly 40 years old. Table 2 also indicates that most of the farmers completed six years of schooling. Respondents replied that education facilities were poor during their time. The majority of farmers were not educated enough to negotiate or obtain market intelligence, even their native language is Bangla. Table 2 also depicts that per month, farmers earn on an average BDT 10,120 and expenditure is on an average BDT 8,971, thus, their average saving is BDT 1,920.

Table 2. Demographic profile of the principal actors in the agroforestry product value chain in *Dumuria* Upazila

	Farmers		
Characteristics	Mean, N	Percentage	Standard Deviation
Age (In years)	40.35	-	8.65
Literacy rate (Schooling year)	-	26.36	-
Income (BDT monthly)	10,120.36	-	3,431.258
Expenditure (BDT monthly)	8,971.00	-	3,675.68
Savings (BDT monthly)	1,920.00	-	1,041.83
	Intermediaries		
Age (In years)	41.35	-	9.75
Literacy rate (Schooling year)	-	25.16	-
Income (BDT monthly)	17,150.38	-	5,655.76
Expenditure (BDT monthly)	12,116.57	-	4,153.86
Savings (BDT monthly)	5,150.23	-	1,967.95

Source: Author's compilation based on a filed survey, 2019.

The average age of the intermediaries was around 41 years as presented in Table 2. The literacy rate of the intermediaries indicated that they had an education level on an average up to class seven. Table 2 also describes that intermediaries earn per month on an average BDT 17,150 as well as their monthly expenditure was on an average BDT 12,116. Hence, their monthly average saving was BDT 5,150.

Agroforestry-based crop value chain in Dumuria Upazila

The field investigation revealed that there were numerous marketing outlets for agroforestry goods. Sometimes, the farmers themselves sold the product. Sometimes, other channel members such as *phoria* (middleman), *bepary* (trader), *and paiker* (wholesaler) helped in the marketing of the products. The existing marketing channels are depicted in Figure 3.

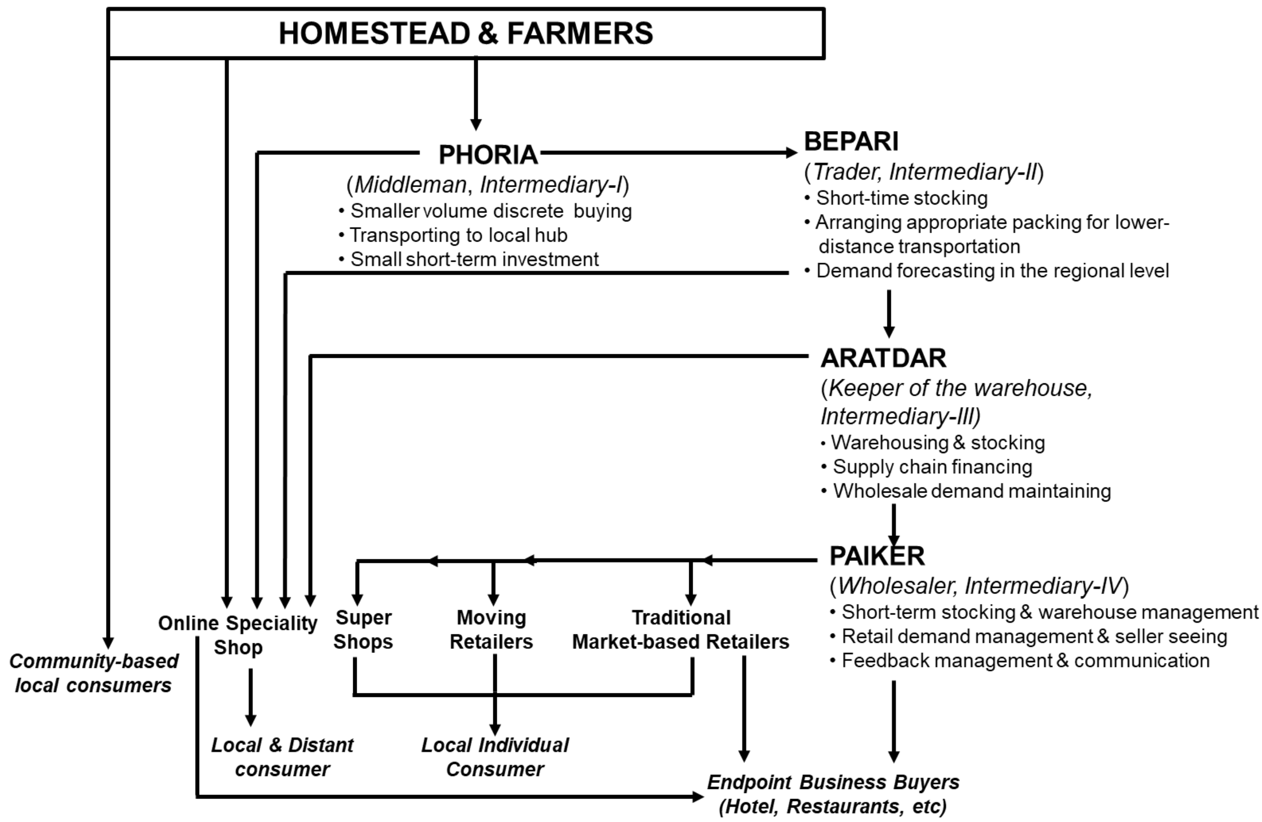

Figure 3. Stylized schematic diagram of agroforestry-based crop value chain in the study area based on a filed survey, 2019

In this study, for agroforestry crops, the primary and most prevalent network structure is made up of *farmers*, *phoria* (middleman), *bepary* (trader), *aratdar* (keeper of a warehouse), retailer and consumer. While advanced online marketing is a vast network of platforms into which marketers must essentially integrate their products, online advertising is far more sophisticated than the networks themselves. Consumers can directly buy their desirable products directly from the online platform from any of the actors including *bepary* (trader), *paiker* (wholesaler) or others. Other network structures were farmer to trader to keeper of a warehouse to retailer to consumer; farmer to trader to retailer to consumer; farmer to trader to consumer; farmer to retailer to consumer; and farmer to middleman to consumer respectfully. Network structures of agroforestry crops and the pathway of agroforestry crop distribution channels are illustrated in Fig. 3. According to the field data, *bepary* (trader) controlled the majority of crop items in these network structures in order to maintain marketing operations whereas *paiker* (wholesaler) was the next most important intermediary who further distributed the products (Figure 3).

Agroforestry-based Wood value chain in Dumuria Upazila

The timber industry in Asia has been well incorporated into the global economy. Though timber raw materials are partly sourced from overseas, timber goods are sold on domestic and foreign markets. The composition of the value chain of timber is influenced by unique product characteristics with socio-economic, political and environmental factors. In Bangladesh, the presence of numerous middlemen is quite culminated in a very complicated timber value chain. The typical timber value chain involves farmers, farmer groups, village traders, timber depots and processors. In Bangladesh agroforestry (general) timber products vertical network structure has four diverse channels and the prevalent one is the homestead and farmer to local trader to fuelwood *aratdar* (supplier) to consumer one. However, other network structures were farmer to local trader to retailer to consumer; farmer to local trader to consumer; and farmer to local trader to sawmill to consumer. In typical agroforestry schemes, farmers sell their items directly to the intermediaries; Figure 4 shows the locations of each intermediary and timber distribution chain. This study also demonstrates that farmers sold the majority of their firewood to neighborhood traders, who in turn sold it to sawmills, brickyards, rice mills, and then directly to customers. However, wholesalers only sold a third of their goods to retailers, with the remaining little amounts going to domestic businesses (e.g., furniture industries, cottage industries). The forest-based industries in Bangladesh typically adopted a cost-management approach consisting of large-scale processing of generic low-value goods with a low assortment capacity. While it is hard to extrapolate value creation in chains, the uneven allocation of profits between chain members has been observed in most situations. Small to medium sized businesses and small-scale manufacturers typically gained the least in their chains, showing the immediate need to upgrade the value chain, which was successful in other countries.

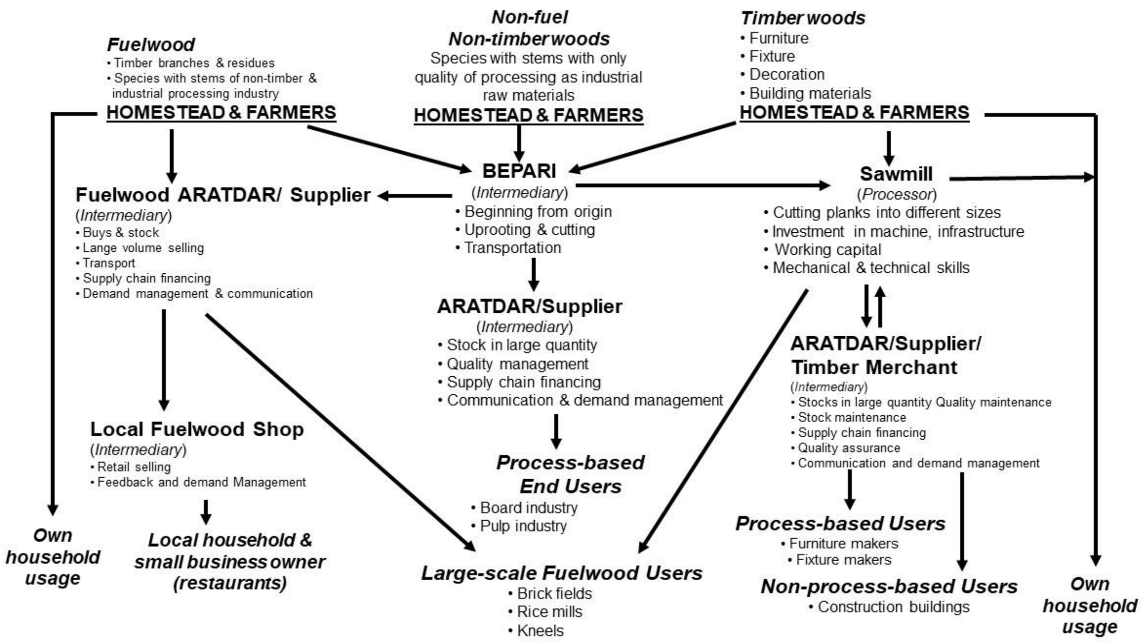

Figure 4. Stylized schematic diagram of agroforestry-based wood value chain

Value absorption and gain sharing in the functional levels of the agroforestry value chain in Dumuria Upazila

In this study, the prices of the primary crop used in agroforestry and timber including babla (*Acacia nilotica* L.) are described intermediary-wise in Table 3 and Table 4, respectively. Table 3 shows that the marketing costs of vegetables include all expenses paid to various intermediaries such as *phoria* (middleman), *bepary* (trader), *paiker* (wholesaler), retailer and farmer. During their dissemination along the value chain network, vegetables gained more value. Results revealed that the share of transportation cost was the highest (61.19%) followed by damaged (17.38%), labor wages (6.41%) and donation (6.41%) (Table 3). The total value-added cost per 100 BDT (1US$ = 84.96 BDT as on December 2002) vegetable products was Taka 1561.5 from production to consumption. Among the intermediaries, the retailer total cost was the highest followed by the wholesaler (Table 3).

Table 3. Value concentration structure in the vegetable value chain in *Dumuria* Upazila

Cost items of vegetables (per 100 BDT)	Intermediaries							
	Farmer/ Homestead	*Phoria* (Middleman)	*Bepary* (Trader)	*Aratdar* (Supplier)	*Paiker* (Wholesaler)	Retailer	Total	% of total cash
Transportation	105.5	-	205	210	225	210	955.5	61.19
Labor wages	10	10	15	25	15	25	100	6.41
Bazar toll	10	-	10	-	-	-	20	1.28
Noninstitutional expenses and business	10	10	20	25	20	15	100	6.41
Damage	5	15	35.5	40	55.5	120.5	271.5	17.38
Self-expenses	10	-	10.5	14	13	15	62.5	4.00
Others	-	5	10	14	13	10	52	3.33
Total	150.5	40	306	328	341.5	395.5	1561.5	100

Source: Author's compilation based on a filed survey, 2019

Table 4. Value concertation structure in the firewood babla (*Acacia nilotica* L.) value chain in *Dumuria* Upazila

Cost items 1mon= 40kg	Intermediaries							
	Farmer/ Homestead	*Phoria* (Middleman)	*Bepary* (Trader)	*Aratdar* (Supplier)	*Paiker* (Wholesaler)	Retailer	Total	% of total cash
Timber harvesting	8.5	-	-	-	-	-	8.5	10.96
Transportation	2.5	2.5	4.5	10.5	5.5	7.5	33	42.58
Labor wages	2	2	2	4	2	2	14	18.06
Bazar toll	0.5	-	1	1	-	-	2.5	3.22
Noninstitutional and non-business expenses	-	0.5	1.5	2	-	2	6.5	8.38
Self-expenses	0.5	1	1	1.5	1	2	7	9.04
Others	-	0.5	1.5	2.5	-	2	6	7.75
Total	14	6.5	11.5	21.5	8.5	15.5	77.5	100.00

Source: Author's compilation based on a filed survey, 2019

Value added could readily demonstrate how much more each item would cost through the marketing channel. Agroforestry products were transported through value chains, where each intermediary charged a fee on top of the actual expenses. According to Table 4, the price of 40 kg of acacia timer was Taka 77.5. Besides this, the transportation expenses for acacia timber (42.58%) were highest, followed by labor costs (18.06%). *Aratdar* value added costs were highest among the intermediates, followed by retailer value added costs. Therefore, the cost of the item will increase as the value chain's frequency of intermediaries increases. The majority of the expenditures associated with adding value to a product are related to transportation, which can be readily reduced by eliminating intermediaries from the value chain. There were also certain unforeseen expenses, including tips and contributions, bazar toll, and these might be easily reduced by following marketing standards and regulations.

Discussion

The idea value chain analysis has partly emerged as the synonym of market analysis. It focuses on the exploration of the actors who are horizontally locked in an interdependent and transactional relationship for constructing and reaching the finally consumable product or service in the end market. The chain as a whole and the particular transaction node in the chain are subject to different rules, norms and enforcement mechanisms in different institutional and spatial levels. In the developing countries, the majority of poverty reduction and regional development policies are focused on improving agricultural productivity and encouraging market access and smallholder farmers' entry into structured market exchanges. Our analysis of the agroforestry value chain has explored the actors and their roles in the value chain, value accumulation nodes, and respective concentration of value (expressed in the cost=income terms) in the chain nodes. This study has been enriched with an analysis of network and value-added structure study of various intermediary types along with an understanding of how this channel works. Our analysis has explored a wide array of the intermediary actors with specific functionalities and complex interrelations which is not outwardly comprehensible for a seemingly simple and localized value chain like agroforestry value chain. Role of the actors, their alignments, and their economic rent seeking capacity (Dalemans et al., 2019) are found to be clearly distinctive in the case of wood segment and crop segment of the agroforestry value chain we have studied. In case of agroforestry crops, the structural part of the value chain is consisted of six actors while the most expanded and populated span of the structure incorporates the intermediary network consisted of *phoria* (middleman), *bepary* (trader), *paiker* (wholesaler) or *aratdar* (keeper of a warehouse) and retailer. This intermediary network connects the farmer in the upstream and consumers in different locations in the downstream. Economic rent seeking behavior of the intermediaries takes place more in the agroforestry crop value chain due to higher intensity of the intermediaries with varying degree of value generation in their respective nodes (Kistruck et al., 2013). Shorter span and less populated intermediary network, in case of agroforestry wood value chain in *Dumuria* Upazila, is associated with less rent seeking in this particular chain.

Agroforestry value chain in *Dumuria* Upazila in Khulna reveals the typical market power concentration among the intermediaries, which is a typical feature of the agricultural and natural resources value chains in the developing countries in particular. Market power emerges from asymmetric possession of end-market knowledge, strategic position in the market network, and investment capability. In crop and wood value chain *Paikar* and *Aratdars* (large wholesale buyers and warehouse keepers who are the connected to the downstream of the respective value chains) have appeared to be the most powerful actor who have determinant influence of market supply and price. Such power of them is associated with their experiential expert knowledge about the product, market networking and relations management capability, large buying capacity, inventory management and hoarding capability. Besides this, the farmers/homesteads are typical price takers in this value chain without significant bargaining power. This is due to their smaller and fragmented nature of farming and small size of the individual output cut off their bargaining capacity as no individual farmer/homestead can influence market supply. Individual famers/homesteads don't have capability and skills for product grading, inventory carrying and management, and coordinating and networking with the end market. This is a typical position of the farmers/homesteads in the agricultural and agroforestry value chain. Intermediaries have the demand, product, distribution, and the network management capabilities in terms of appropriate skills, investment, and risk assumption. In particular, *Bepari,* in the agroforestry crop value chain in *Dumuria* Upazila*,* appears to be the largest rent seeker in this value chain. The prevalence of retailers in the crop value chain is consistence with the nature of consumers market of unprocessed agricultural food items. For more democratization of the gain and welfare distribution in the agricultural and smallholder dominated agroforestry value chain, upgrading of the farmers/homesteads in terms of their product customization, demand management and networking capability can help shedding of the purer rent seeker intermediaries in the value chain. Development of farmer/homestead agroforestry networks, in the form of cooperatives, in *Dumuria* Upazila can work as a primary-level intervention mechanism. Farmers/homestead cooperatives has been proven successful in upgrading and capacity building in the agroforestry value chain as well as democratizing the value chain both in the developed and developing country context (Poole & Donovan, 2014; Schoneveld, 2022). Pro-market redefinition of the role of the intermediaries may led to restructuring the existing agroforestry value chain in Bangladesh. This study in *Dumuri*a Upazila is a typical representative study of agroforestry value chain in Bangladesh, which can help in democratizing the value chain through rationalizing the economic rent and gain among the participants in the value chain based on their measurable and quantifiable contributions in the value buildup. Such redefinition of the intermediaries requires policy interventions (Thiele et al., 2011; Tseng & Shang, 2021) as well as participatory integration of value innovation focused market actors including large processing and manufacturing industries and retailers (Rossi et al., 2019).

Conclusion

Analysis of the agroforestry value chain in *Dumuria* Upazila in Khulna in Bangladesh reveals the structure and issues typical to similar value chains in similar other developing countries. Analysis of such simple value chains is important as the downstream of such value chains have stronger local and regional embeddedness. Local economic development and social upgrading is highly linked with the functioning and developmental quality of such value chains. Poverty reduction and strengthening the social safety nets in the developing countries are linked with pro-market and pro-poor value chain development. Rationalization of agroforestry, value chain may work as high-potential supplemental intervention in this regard along with development of other major industrial and natural resources value chains. Analysis of the agroforestry value chain in this case reveals the strategic and policy infliction points for realizing the pro-poor value chain development focused approach of local and regional economic development. Appropriate policy framework and engagement of the local government in agroforestry value chain facilitation may include value chain financing arrangement and infrastructure facilitation in the form of warehousing facility development. This paper was primarily focused on a case-specific exploration of the structure, actors, relational dynamics, and patterns of value aggregation in the agroforestry value chain. Findings and learning of this research mark the areas for further research on the exploration the types social and institutional innovations for development of inclusive and sustainable agroforestry value chain, governance mechanism for democratizing the agroforestry value chain for sustainable regional development, and identification of the required capabilities and ways of capacity building in the downstream of the agroforestry value chain for competitiveness development of the smallholders.

Conflict of Interests

The authors declare no conflict of interest.

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ORIGINAL ARTICLE SCIENCE & ENGINEERING

FLOOD VULNERABILITY AND ADAPTATION PRACTICES OF RESIDENTIAL AREAS IN ABUJA, NIGERIA

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Abstract

The increasing effects of flooding in flood-prone areas over the years cannot be overstated in terms of reducing flood damage. There are several measures of various characteristics, each of which has its own justification in flood protection. The concepts of vulnerability, hazard, and risk have been extensively used in various disciplines with different meanings, impeding cross-disciplinary cooperation for dealing with hazardous events. In Nigeria, there has been an occurrence of flooding and many households have been rendered homeless and many lives have been lost due to this devastating issue. This article aimed to examine flood vulnerability and possible adaptation practices for residential buildings as well as the potential for resiliency in the event of its occurrence. The objective was to propose appropriate resilient strategies to mitigate flood risk in Abuja, Nigeria. The paper adopts a purposive sampling technique in the selection of some areas for the study. A structured questionnaire survey was used to get information on the residents, and also a site risk assessment was taken on the selected areas. A total of 174 questionnaires were administered, with a valid rate of 96.6% and a reliability value of 0.606. The result shows that an average percentage of residential areas are affected by floods with low resilience strategies. The study concludes that the government should have policies to set the rules of implementation and possible resilience strategies to mitigate the occurrence of floods for the residents.

Keywords: Flood risk, vulnerability, hazard, residential properties, resilience

Introduction

The world is affected by natural disasters on a yearly basis, with flooding having one of the greatest damage potentials of them all (John-Nwagwu, et al., 2014). Flooding, as defined by Getahun and Gebre (2015) is the surplus flow of water which surpasses a river channel's carrying capacity, drainage system, dams, and any other water bodies. Meanwhile, Oyebode (2021) expanded further to describe flood as the most expensive and one of the deadliest natural disasters in the world. Flood occurrence reportedly dates back to the 16th century and according to USDC (2011) has caused massive loss of lives, destruction of property, and degradation of farmlands.

In recent years, the effects of flooding have become increasingly common at an increasing scale and severe as a result of increasing population growth and human interventions such as socio-economic activities in the floodplain (Abdullah et al., 2019). This has led to massive loss of life and property as a result of the ingress of water into developed physical infrastructure. In Africa, the number of people affected by floods in East Africa alone, as reported by BBC (2020), was estimated at about 3 million between 2016 and 2019. In Nigeria, according to Ayoade (1985) and Okeke (2006) cited in Obeta, (2014), floods have also been a reoccurring and increasing issue, causing a lot of disaster to socio-economic activities.

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In the year 2012, Nigeria recorded a total of 363 deaths, 597,476 destroyed houses and close to 2.3 million people displaced due to flooding (NEMA, 2013). In Abuja, the Federal Capital Territory (FCT) of Nigeria, areas such as Gwagwalada, Lokogoma, and Lugbe environs have reported massive rises in water levels, causing varying levels of property damage as well as loss of life. The effect has resulted in environmental degradation, as illustrated in Plates 1 and 2.

Plate 1. The flood affected area in Trademore Estate Lugbe, Abuja, Source: Adenekan (2021)

Plate 2. The flood affected area in Lugbe, Abuja. Source: Adenekan (2021)

Given the intensity and scale of the danger arising from floods, it is observed that many housing design and construction techniques in the study area do not take cognisance of environmental health challenges arising from the effects of flood into consideration and how they could be addressed. Hence, measures that need to be put in place to ensure the resilience of buildings and other infrastructure at risk to prevent possible damage are grossly lacking. The non-conforming housing design and construction techniques required to tackle flooding in the events of its occurrence forms the basis for this study. This study highlights the level of risk residential environments in Abuja, Nigeria is exposed to due to flooding and the assessment of how the risk could be mitigated. The study is generally driven by two key objectives: (1) to investigate the risks residential buildings are prone to as a result of flooding and (ii) to determine the flood resilient strategies that could be employed to mitigate flood risk to residential building occupants.

Review of Literature

In the literature, the incident of flooding has been viewed from many perspectives. Obeta (2014) indicated that flooding has caused a serious negative impact on people due to its devastating nature. The growing number of flood victims, as well as the impediment to sustainable development, demonstrates little knowledge of flood resilience strategies (Nkwunonwo et al., 2016). Adetunji and Oyeleye (2018) opined that potential victims of flood disasters are often affected by limitations which force them to live within flood plains. This is characterised by an absence of zoning regulations, flood control, emergency response infrastructure, and early warning systems (Oyebode, 2021). Based on Nwigwe and Emberga (2014) perspectives, flood is viewed as the occurrence of an unfortunate incident that can be caused by either natural causes. For natural causes, this could be heavy or torrential rains while human causes could be as the result of construction flaws resulting to dam failure, broken water pipes, and leakages.

Noren et al. (2016) postulated that humans play a part in the occurrence of natural disasters through such activities as illegal use of drainage channels, land reclamation, and poor physical planning, amongst others. Deforestation, development in technology, industrialization, urbanization, burning of fossil fuels, and agricultural activities are other notable causes. Among other notable causes of floods is climate change through which the rise in global temperatures can result in severe floods in several regions of the world. This particularly exacerbate the incidence of flooding by increased weather unpredictability (Agbonkhese et al., 2014) prolonged periods of rainfall leading to destructive effect of floods on built properties.

A concept rooted in how people or societies are likely to be affected by flood phenomena is termed vulnerability to flood occurrence. It is the sensitivity of the community or people to flooding considering the socio-economic, environmental and physical components which can be understood through an assessment of flood vulnerability components and factors. According to Intergovernmental Panel on Climate Change (IPCC, 2007) vulnerability is the degree to which a system is susceptible and unable to cope with adverse effects of climate change. It quantifies the associated risks within the context of environmental and socio-economic capacity to adapt to flood events. Scoones (1998) posited that flood vulnerability is influenced by personal or group characteristics in terms of their capacity to anticipate and cope with the impacts of flood. However, for vulnerability to exist, the capacity of the population to absorb, respond and recover from the impacts must be taken into consideration as postulated by Ngie (2012).

An IPCC (2014) report viewed vulnerability as an already-existing condition that is assessed without the use of exposure indicators (to hazard). As a result, markers for a system's intrinsic qualities of "sensitivity" and "adaptive capability" are used to evaluate it. On the hand, adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). Different social groups or classes within a society are differentially at risk, both in terms of probability of occurrence of an extreme flood event and helping different classes to recover (Cardona 2003; Nethengwe, 2007).

Vulnerability has two phases: an external side of risks, shocks, and stress to which an individual or household is exposed; and an internal side of defenselessness, which refers to a lack of resources to cope without suffering irreparable loss (Agbonkhese et al., 2014). It exposes the building structure to risk, which affects the functionality and efficiency of the built environment. Thus, when considering vulnerability and adaption, resilience is an important factor that must not be overlooked. Adebimpe et al. (2018) expressed that resilience is the capability to encompass or recuperate from disruption in a reasonable time. Structurally, buildings including the materials with which they are constructed must be able to withstand the stress associated with high-impact floods. Bowker et al. (2007) cited in Ezeokoli (2019) stated that achieving flood resilience in buildings is through durable construction done in such a way that water can enter the building but the impact will be reduced.

Two main approaches to resilience are presented by Holling (1973) cited by Tri et al. (2017) as engineering and ecological approach. While engineering resilience deals with the capacity of a system to return to a stable equilibrium following a disturbance (Holling, 1973, cited by Tri et al., 2017) ecological resilience on the other hand represents the dynamics of the system focusing on preserving the engineering systems' functional stability. Through various equilibria, ecological resilience investigates how the system might adapt and reorganise itself. The ability of an ecosystem to withstand disruptions, be ready for future floods, and integrate multiple resources are all aspects of ecological resilience (Liao, 2012). The ability to learn from each flood and adapt the system to internal and external changes is an indication of ecological and attribute of ecological resilience.

Nkwunonwo et al. (2016) referring to the need for a form of resilience argued that there is need for coping and adaptation strategies to climate change as the impacts of flooding increase significantly with threatening proportions resulting in loss of life and property to urban dwellers and flood victims. This argument was initially advanced by Anunobi (2013) who expressed that some form of adaptation to flood risk disaster is essential. Meanwhile, Batica (2015) in their survey carried out using a survey approach on flood resilience assessment in urban environments and mitigation strategy development argued that the basic function of resilient buildings is to prevent water from entering the building and provide the possibility of normal activities in the environment.

COH (2015) demonstrated how resilient buildings can be achieved through the use of materials such as concrete, steel, treated plywood, glass, and many others for various aspects of building components. Within the guidelines, materials to avoid for flood resilient buildings such as engineered wood laminate flooring, carpeting, wood flooring, cork, fiberless insulation, wallpaper, plaster, cork and many others were also highlighted. The guidelines further provided some guides as strategies such as using Design Flood Elevation (DFE). This is the elevation to which construction is regulated. It is determined as DFE = BFE+Freeboard. BFE stands for Base Flood Elevation and while Freeboard stands for specific height above the anticipated flood elevation (COH, 2015). This strategy makes provision for flood protection, prevention, and preparedness which according to Zevenbergen et al., (2020) are all priorities for resilient strategies for buildings of the present and the future.

Building strategies for flood-prone areas as opined by Lukasz and Magda (2020) are based on two opposite concepts namely avoiding and resisting. When water overflows into the built environment, it could cause dampness to buildings through capillary action, which invariably damages the building material and its structural stability. Hence, the need for strategies to avoid water intrusion into the building calls for avoidance technology as part of resilient strategies to reduce the risk of vulnerability of buildings and other physical infrastructures to improve safety and protection of socio-economic activities. Therefore, the use of existent techniques from time past employed in mitigating flood risk and creating a road map for maximum adaptability of buildings to the effect of flood becomes necessary.

Adaptation and risk (vulnerability, exposure) in response to flooding (hazard)

In the rapidly urbanising world, floods are wreaking increasingly more havoc, with disproportionately large consequences for the most vulnerable and disadvantaged (Jongman, 2018). Effective adaptation plans that include infrastructure for flood protection, natural solutions, and risk finance schemes are required to manage floods and mitigate their financial effects. The annual cost of damage would be reduced by hundreds of billions of dollars, and the number of people living in extreme poverty would decrease by 26 million people if all natural disasters could be abruptly and completely abolished (Hallegatte, 2017). Disasters, however, cannot always be avoided. A variety of interventions are necessary for effective adaptation to growing flood risk, including structural flood protection measures, early warning systems, risk-informed land planning, nature-based solutions, social protection, and risk financing mechanisms (Aerts et al., 2014). However, in places with high population and asset concentrations, physical flood protection systems like dikes and levees are typically cost-effective (Ward et al., 2017).

The Netherlands is the best example of a nation that largely relies on such structural measures because it is both densely populated and highly susceptible to flooding. A dike system that offers protection against disasters that only happen once every 10,000 years covers the majority of the shore (Jongman, 2018). However, such protection measures necessitate substantial capital expenditures for both construction and upkeep, which political momentum and government budgets frequently fail to cover. According to Temmerman et al. (2013), governments have recently been using nature to control flooding. These naturally occurring alternatives include enlarging natural floodplains; safeguarding and developing wetlands; reviving coral and oyster reefs; and investing in urban green spaces to lessen run-off. These adaptation methods have been used in the United States, where natural wetlands are thought to have saved $625 million in Hurricane Sandy damage (Narayan et al., 2017).

Nature-based adaptation strategies in the Gulf of Mexico might even cut overall risk by an astounding $50 billion, with an average benefit to cost ratio of 3.5 (Reguero et al., 2018). The nationwide "Sponge Cities" programme of China has begun implementation in 16 pilot cities, where enormous amounts of green space will be incorporated into urban planning to minimise surface flooding (Jongman, 2018). Nature-based solutions can have a wide range of advantageous benefits for ecosystem protection, carbon sequestration, tourism, and local employment, in addition to significantly lowering flood risk. Various stakeholder groups must frequently be involved in the implementation of natural techniques, assisting with awareness-raising and consensus-building.

Amphibious Building Techniques and Less Flooding

Elizabeth et al. (2017) pointed out that an amphibious flood mitigation system consists of two basic parts. For homes in places where rising flood levels don't come with high flow rates, amphibious foundations provide a practical, liveable option to permanent static elevation. This term refers to retrofit construction in which buildings are elevated on vertical structural supports to a height above the projected 100-year flood level, i.e., putting a building "up on stilts" (English et al., 2016). Basic amphibious operations require vertical guiding to avoid lateral movement and buoyancy to allow momentary flotation. A house is more resilient to flooding in recognition of the variable elevation, which does so without permanently subjecting the building to stronger winds. Any increase in wind speed and force is minor compared to the exponential rise in force that would occur from permanently elevating the house, as it stays close to the ground until catastrophic flooding occurs.

An existing structure can be retrofitted with a buoyant foundation, a flood-mitigation technology that enables it to rise with the water during a flood and securely sink back to the ground when floods subside. This method protects a home from the devastating effects of floodwater and is completely passive, working with changing water levels rather than against them. It guarantees that possessions are safe and that residents won't experience protracted eviction. Three easily constructed components are used in the design of a buoyant foundation: buoyancy blocks to give flotation; vertical guidance posts to direct the movement of the building, and a structural frame to connect these to the existing structure of the house. (Best Climate Solutions, 2006). The Turner et al. (2003) conceptual framework, which shows how vulnerability is a function of exposure, sensitivity, and adaptive capacity, was adopted and adapted for this investigation. The main components of vulnerability are exposure, sensitivity, and resilience. Exposure is the term used when the operational system is altered and operates differently than it would normally.

A system is exposed to external influences that can change its state as opined by Judy et al. (2011). The existing sociological and ecological conditions have made the system vulnerable. The chance or potential for a danger to have an effect on the system is known as susceptibility. Susceptibility, according to Samuels et al. (2009), is the likelihood that floods will have a detrimental impact on the environment and society. A risk could affect both the socioeconomic environment and the natural environment. According to Galderisi et al. (2005) resilience is the ability of a community to modify itself to reach an acceptable structural and functional level in the face of changes in a dangerous region. This calls for the system to be robust, or to be able to continue operating and performing its functions after interruptions.

The Intergovernmental Panel on Climate Change (IPCC 2007) defined sensitivity as the extent to which a system is impacted by an exposure, either negatively or positively. Environmental and socioeconomic systems are sensitive to diverse things. Impacts of floods are a major source of sensitive concern. A system may be vulnerable to both direct (physical) and indirect (socio-economic) effects, such as the age structure of the population and the amount to which mortality increases during a heatwave. As an example, a given change in rainfall may have an effect on a city's water supply (Judy et al. 2011). Figure 1 shows the conceptual framework developed for this study to guide the collection of appropriate data.

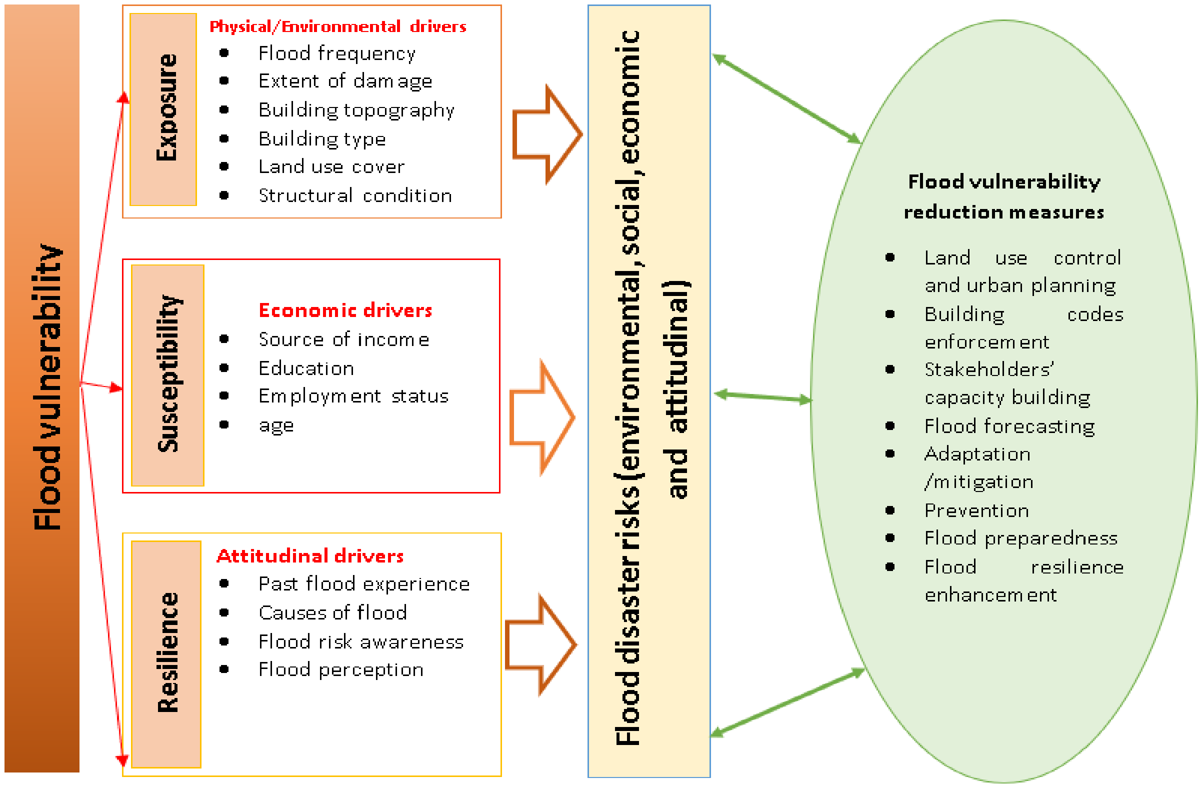

Figure 1. Conceptual framework developed for the study

Materials and Method

Study Site

This study was conducted in the Lokogoma, Galadimawa, Lugbe, Kubwa, and Gwagwalada areas of Abuja, Nigeria. Abuja is the Federal Capital of Nigeria and is located within the North Central geo-political zone of Nigeria. It is bounded on the north, east, south, and west by Kaduna, Nassarawa, Kogi, and Niger states, and has a land area of 7,607 square kilometers. Abuja is geographically situated between latitudes 8.25 and 9.25 north of the Equator and longitudes 6.45 and 7.39 east of the Greenwich Meridian. It is a region with steep, irregular terrain, undulating plains, and is distinguished by varied degrees of harshness Balogun (2001). The sandstone belt in the south-west is only somewhat rugged, while the eastern, central, and south-east regions are the most so.

The north-eastern "pan-handle" side of the FCT contains its highest point. This is located in the Bwari Area Council, where there are numerous peaks that rise to a height of 60 metres. Abuja is made up of six (6) geographical locations (Bwari, AMAC, Gwagwalada, Kwali, Abaji, and Kuje). The study locations are Gwagwalada, which is an area council, and AMAC, where other locations (Lokogoma, Lugbe, Kubwa, and Galadimawa) are situated. The maps showed in Figure 2a and Figure 2b indicates that Gwagwalada and AMAC are the most affected by flood vulnerability.

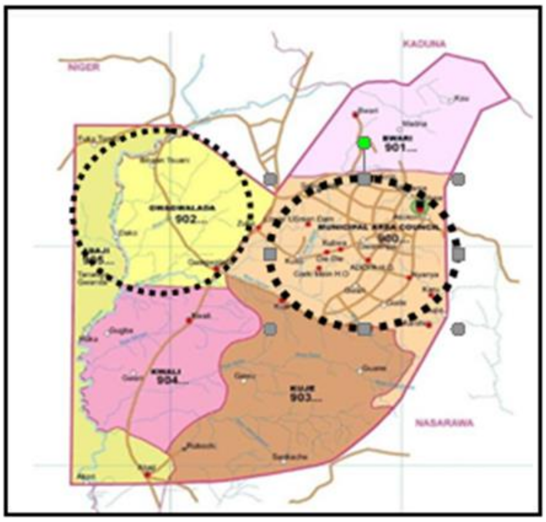

Figure 2a. Study Site map (Abuja)
(Source: Mallo et al., 2021)

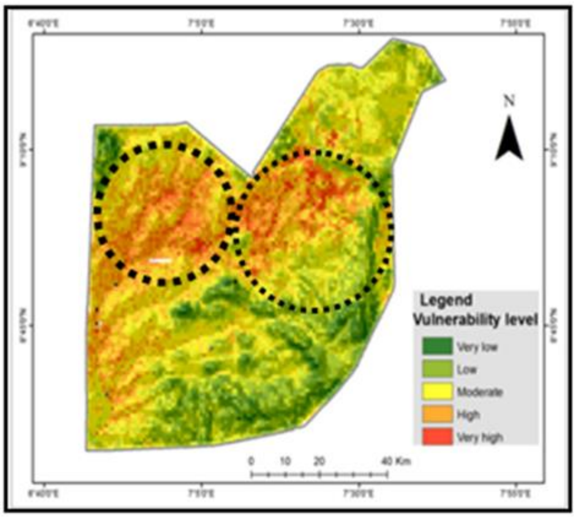

Figure 2b. Flood vulnerability sites in Abuja

Data Collection Procedure

In this study, quantitative research methods were used. In quantitative research, the methodology is more deterministic with defined fundamentals, dictating the strategy or design that should be used. Due to the study's quantitative nature, a descriptive approach was used as the primary method of data gathering. Data for this study was collected from primary and secondary sources to present a description of the phenomenon and the experience of the respondents. Instruments used included a questionnaire survey and a field observation checklist developed by the researchers. The questionnaire contained both closed-ended and open-ended questions in order to elicit information. Primary data was collected via field survey from residents of Lokogoma, Galadimawa, Lugbe, Kubwa, and Gwagwalada areas of Abuja due to largely reported cases of flooding in these areas. A purposive sampling and random sampling technique were utilised in the collection of the primary data. The sites were purposively selected while the respondents were randomly selected.

Purposive sampling was used in accordance with Creswell et al. (2011) views that the researchers intentionally select individuals and sites that hold the required information to elicit data. This method was employed because the research focused on flood-prone residences within the study area alone. The consent of the respondents was sought by explaining the intent of the study. The right of the respondents to withdraw their participation in the filling of the questionnaire was also explained prior to the commencement of administering the questionnaire. Secondary data was obtained from relevant literature, which included journals, press reports, publications, unpublished works, books, and the internet. Research was conducted by consultation and an extensive review of literature pertaining to flood risk and resilience.

Based on data obtained from the National Population Commission of Nigeria (NPC, 2006), the population of the study communities is as follows: Lokogoma has 77,622; Lugbe 3.2 million; Kubwa 776,298; Gwagwalada 442,591; and Galadimawa 8000, which amounts to a total population of 4,504,511. The total number of flood-affected residences in the lowland is 1210 (Table 1). Two hundred and fifty (250) residences were randomly selected as the projected sample size from the five (5) selected communities for the study.

Table 1. Respondents Response Rate

Location	Sampled number of respondents	Distribution (No)	Returned (No)	Response rate (%)
Lokogoma	280	50	41	82%
Lugbe	270	50	43	86%
Kubwa	240	50	34	68%
Gwagwalada	220	50	30	60%
Galadimawa	200	50	26	52%
Total	1210	250	174	69.6%

Reliability and Validity of the Research

A total of fifty (50) questionnaires were administered to each selected sub-area to cater for possible errors amongst the five (5) selected areas, summing to a total of 250 administered questionnaires, out of which 174 were returned with 69.6% as the response rate. With a total of 174 questionnaires returned a valid rate of 96.6% and a reliability value of 0.606 was obtained. Thus, the sample size of 174 is considered adequate for the survey based on the published table by Bartlett et al. (2001) for determining the minimum returned sample size for a given population size of 1000 for continuous data where alpha = 0.05 and t = 2.58. The questions asked covered how often floods occur, the duration of floods, the damage caused, and some resilience measures to mitigate their occurrence. A variety of sources reviewed the survey before it was put into use. A pretest of the survey was conducted on a number of occasions with a small sample size, and the data collection instruments were designed around the results of the pilot research. Flaws that were found during the pre-testing were corrected before the instruments was finally administered to the respondents in order to improve their validity.

Results and Discussion

The following sections present the results of the findings from the survey carried by the study.

Demographic details and background of the respondents

Table 3 shows the demographic profile of the respondents based on gender, age, academic qualification, and level of income of the respondents. The female respondents constitute the largest gender with (58.6%), followed by males with (38.5%), and others with (2.9%). Also, the age range of 40 years and above constitutes the majority with (43.7%), followed by 29-39 years with (33%) and 18-28 years with (23%). As can be observed, the respondents with masters constitute the majority with 84.5%, followed by bachelor's degrees with 12.6% and secondary school with (2.9%). This indicates that the majority of the respondents are educated and the required information about flood risk and its impacts on the communities will be expected. Additionally, nearly half (47.7%) of the respondents earn below N100,000 as their monthly income. This demonstrates the poor low-income level of the respondents.

Table 3. Demographic data of Respondents

Characteristics	Frequency	Percentage	Characteristics	Frequency	Percentage
Gender			Educational qualification		
Male	67	38.5	Primary	5	2.9
Female	102	58.6	Secondary school	22	12.6
Others	5	2.9	Bachelor's Degree	147	84.5
Total	174		Masters		
Age			Level of income		
18-28 years	40	23	Below N20,000	11	6.3
29-39 years	58	33	N21,000-N50,000	20	11.5
40-above	76	43.7	N51,000-N80,000	17	9.8
Total	174		N81,000-N100,000	35	20.1
			N100,000 and above	91	52.3

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Risk encountered by the residents as a result of flooding

The respondents were asked to determine the risk occupants are faced with as a result of excessive flooding. The survey questions range from how often floods occur in the area to the maximum duration of floods. The respondents were presented with four options from very often to never. The result of the first survey question shows that 27% of the respondents rarely experience flooding; 21.3% often experience flooding; and 9.8% experience flooding very often (Table 4). The second survey question was on the duration of floods in the area. The result shows 39.7% of the respondents experienced flooding within 0–6 hours while 23.6% experienced flooding within 7–12 hours (Table 4). This indicates that residents in the area experience flooding with consequential damage.

Table 4. Risk encounter as a result of flood by the residents

Survey questions	Options	Frequency	Percentage
How often flood occur since living in this location	Very often	17	9.8
	Often	37	21.3
	Rarely often	47	27
	Never	73	42
Maximum duration of flood	0-6 hours	69	39.7
	7-12 hours	41	23.6
	12-24 hours	28	16.1
	2 days and above	10	5.7
	No flood	26	14.9

Level of damage to the residents from continuous flooding

Table 5. Damages encounter as a result of flood to the residents

Survey questions	Options	Frequency	Percentage
Building fitting and fixture damaged during flood	Not damaged	41	23.6
	Negligible	43	24.7
	Barely damage	73	41.9
	Serious damage	12	6.9
	Very serious damage	5	2.9
Damaged to exterior wall	Not damaged	19	10.9
	Negligible	43	24.7
	Barely damage	75	43.1
	Serious damage	31	17.8
	Very serious damage	6	3.4
Damage to interior wall	Not damaged	33	19
	Negligible	42	24.1
	Barely damage	63	36.2
	Serious damage	32	15.4
	Very serious damage	3	1.7
Damage to footing and foundation	Not damaged	38	21.8
	Negligible	42	24.1
	Barely damage	61	35.1
	Serious damage	30	17.3
	Very serious damage	2	1.1
Damage to opening such as doors and windows	Not damaged	37	21.3
	Negligible	42	24.1
	Barely damage	59	33.9
	Serious damage	32	18.4
	Very serious damage	2	1.1

Survey questions were also carried out to determine the level of damage the residents encounter as a result of continuous flooding. The respondents were also presented with four options (not damaged, negligible, barely damaged, serious damage, and very serious damage). The result in Table 5 shows that the building fittings and fixtures are barely damaged by flood with a percentage of the respondent being 41.9%. The exterior walls of the building are barely and seriously damaged by flood with a percentage of the respondent being 43.1% and 17.8% respectively. The interior walls of the building are barely and seriously damaged by flood with a percentage of the respondents being 36.2% and 15.4%. The footing and foundation are being affected by flood barely and seriously with a percentage of the respondents being 35.1% and 17.3%. Also, the openings are being affected by flooding barely and seriously, with a percentage of the respondents being 33.9% and 18.4%. The result shows that there are still areas that experience serious damage as a result of flooding

Flood occurrence within each community in the study site

Figure 3 shows the data from the respondents on the occurrence of floods in each community in the study area. The respondents were presented with 4 options (very often, often, barely often, and never). The result shows that the occurrence of floods is often experienced but not on a regular basis. According to the obtained data, Galadimawa records 1%, Gwagwalada 4%, Kubwa 5%, Lokogoma 4%, and Lugbe 3% of regular flooding (Figure 3). This shows that there are still occurrences of flooding in the area and suggests that measures should be taken to mitigate its occurrence or provide adequate resilience. Due to excessive flooding, there is a need to maintain and protect the floodplains and build infrastructure. According to Ward et al. (2017), in places with high population and asset concentrations, physical flood protection systems like dikes and levees are typically cost-effective. Overflowing and possibly flooding will occur if flood waterways are not maintained.

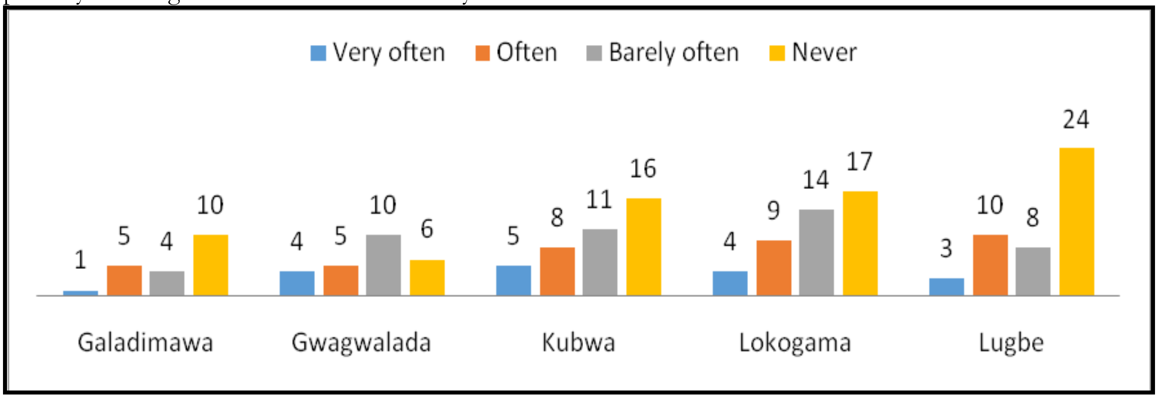

Figure 3. Frequency of flood in the study area

Damages experienced as a result of the flood

Figure 4 shows the data of the respondents on the damages experienced as a result of the flood. 17% of the respondents experienced damage due to building fittings; 35% experienced damage to exterior walls and 25% experienced damage to interior walls; 9% experienced damage to footing and foundation; and only 7% of the respondents experienced damage to openings such as doors and windows.

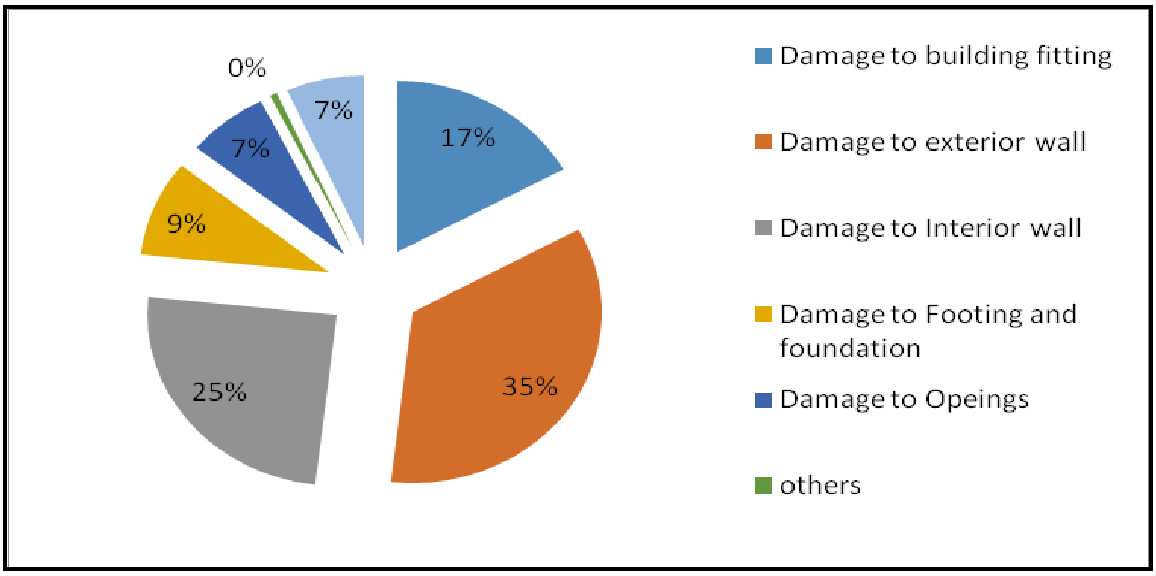

Figure 4. Data of level of damage by flood

Flood related problems associated with the building

Figure 5 shows the data of the respondents on the problems encountered as a result of the flood. 12% of the respondents experience negative health outcomes, 11% of the buildings collapse due to flooding, while 29% of the respondent's experience moisture, and 15% of the respondents' materials deteriorate due to flooding, and only 1% of the respondents die due to flooding. The result shows that the residents still suffer different degrees of problems due to the occurrence of floods in the area. Azad et al. (2013) stated the devastating effects of floods on human beings in Bangladesh. The authors stated the effects as loss of life, food scarcity, increase in disease, loss and destruction of property, damage to farm crops, and increased in-woman vulnerability. This shows that the occurrence of floods has many negative impacts and affects the residents generally, especially women.

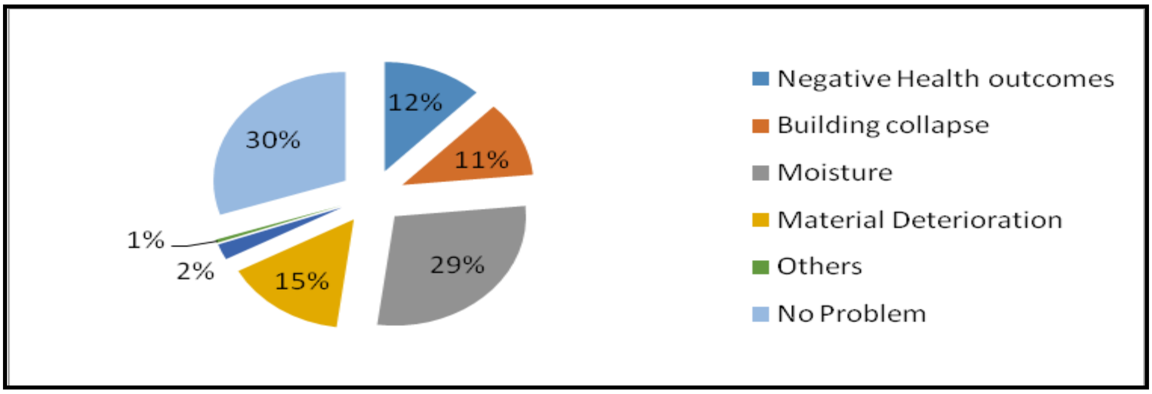

Figure 5. Flood related problems associated with the building

Presence of flood resilience in sampled sites

To determine the flood resilience strategies that could be employed to mitigate flood risk to the residential building occupants, Table 6 shows the data from the respondents to determine how resilient the structures are to flooding. The respondents were given four variables (completely inadequate, inadequate, adequate, and very adequate) to determine the flood resistance of the structures. The result shows that 48.9% of the sampled respondents state that there are inadequate resilience features to mitigate floods in the residential buildings in the study area.

Table 6. Presence of flood resilience in sampled sites

Variables	Frequency	Percentage Frequency	Valid Percntage	Cumulative percent
Very Adequate	7	4.0	4.0	4.0
Adequate	61	35.1	35.1	39.1
Inadequate	85	48.9	48.9	88
Completely Inadequate	21	12.0	12.0	100.0
Total	174	100.0	100.0	

Measure taken to prevent the building from flood

Figure 6 shows that 31 of the respondents applied temporary barriers to control flooding; 54 of the respondents-controlled flooding by channelling the water away from the building; 33 of the respondents used elevated or raised floors; and lastly, 66 of the respondents used water proofing as a measure to prevent the building from flooding. The result shows that the residents adopt resilient ways to mitigate floods in the areas.

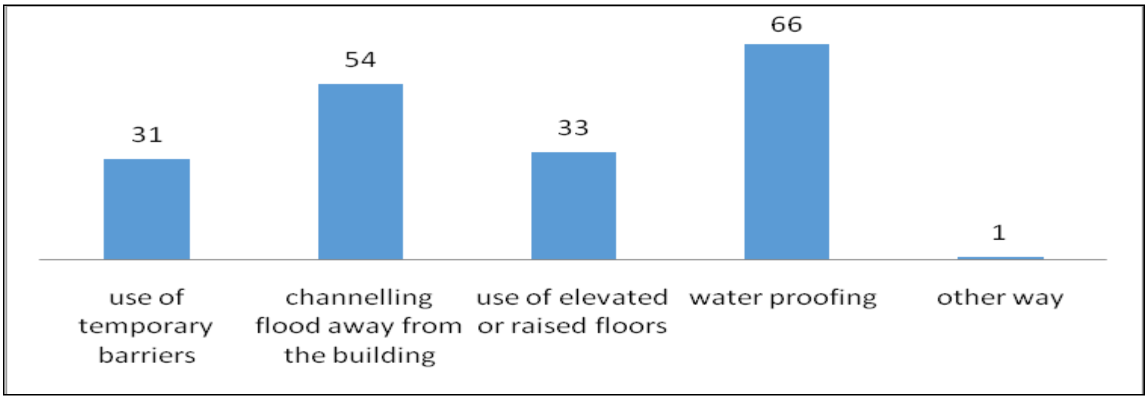

Figure 6. Measure taken to prevent the building from flood

From Table 7, the measures taken by the respondents to prevent the building from being flooded only yielded a low result, as only 25.3% of the respondents were satisfied that the measure, they had taken actually caused a reduction in flood risk. This percentage is very low; this implies that other measures need to be adopted in order to reduce flood risk, as the initial measure did not result in a reduction in flood risk.

Table 7. Impact of flood resilience

Variables	Frequency	Percentage Frequency	Valid Percntage	Cumulative percent
Very Satisfied	15	8.6	8.6	8.6
Satisfied	44	25.3	25.3	33.9
Not Satisfied	63	36.2	36.2	70.1
Very Satisfied	52	29.9	29.9	100.0
Total	174	100.0	100.0	

Discussion of findings

The field observation surveys were carried out in Lugbe, Kubwa, and Gwagwalada areas of Abuja, Nigeria to show the extent of flood risk damage to residents of these areas. The surveys show that most of the buildings have been affected by the menace that triggers the buildings' vulnerability to flooding and endangers the residents' life. The majority of the buildings were completely destroyed, and some are inhabitable due to damage. This finding is in line with the outcome of Douglas (2017) cited in Atufu and Holt (2018) who found in their study on the effects of flooding in Lagos, Nigeria having grave consequences that affect day-to-day life of the residents.

In addition to this finding, the study also stated that damage to property is the most affected of the listed impacts by the flood. It was discovered that nearly half of the respondents (47.7%) earn less than N100,000 each month. This reflects the respondents' low-income status. This finding supports Coutio's (2004) claim that poverty is a major factor that increases vulnerability and impacts of floods, which are likely to last longer among the poor because people who live in flood-prone areas have fewer options for evacuation and are more vulnerable to flood-related diseases, which can be fatal.

The study also found that the majority of respondents were women over the age of 40, supporting the assertion of Few et al., (2003) that marginalised groups, such as the elderly, disabled, and women, are particularly vulnerable and have fewer social powers, economic resources, and physical capacity to anticipate, survive, and recover from the effects of massive floods. This is especially true given Pilon's (1999) contention that gender-biased attitudes and stereotypes might complicate response and lengthen recovery time from flood repercussions. Thus, Considering the risks with consequential damage encountered by the residents as a result of flooding it is necessary to consider some adaptation and mitigation strategies such as an amphibious flood mitigation system and flood-mitigation technology that enables an existing structure to rise with the water during a flood and securely sink back to the ground when floods subside. This could serve as protection measures for the houses from the devastating effects of floodwater. This view supports the assertion of De Graaf (2008) measures to reduce flood vulnerability such as damage prevention, damage reduction, damage reaction and damage anticipation. This strategy is completely passive and work with changing water levels rather than against them.

The measures will go a long way to assist when such a menace occurs and could also avert the occurrence of damages to the buildings and the residents as well as to reduce vulnerability. Owing to the level of damage posed to the residents from continuous flooding, this calls for certain measures to be taken at the professional level such as during the planning stage by the professionals to identify the flood-prone areas to ensure that the buildings are located outside the known hazard areas. Human interference with natural processes to a large extent, where possible, should be limited and/or avoided. The appropriate use of land use control and enforcement certain building codes and policies to guide developers on building on waterways could mitigate the rate of flood disasters in the environment.

Recommended Strategies for Residential Building Resiliency

Floods are becoming more common in Nigeria. As a result of the findings of this study, proposed flood risk mitigation solutions for residential buildings should include resilience adaptable strategies. Such as keeping flood water out (dry flood-proofing) or preventing flood water by raising the building or allowing flood water to take action while reducing damage (wet flood-proofing). Figure 7 depicts examples of resilience adaptive site techniques that could be used, as adapted from Burden (2013) and cited in Sholanke et al., (2021). As mentioned in the literature, other resilience measures stated like robust or durable construction and the materials used and the integration of using design flood elevation (DFE) to achieve a specific height above the anticipated flood elevation are further recommendations. The building should be designed to operate in a flood zone at a height of three feet above the projected flooding occurrence. Other additional strategies needed for residential building resiliency include:

- **Location of projects outside of known hazard sites**
  Designers should advocate for project sites outside of flood-prone areas so that design efforts and construction can be focused on maximising operational efficiency. Development should concentrate on areas safe from hazardous flooding to ensure a reduction of future losses.

- **Maintenance and protection of floodplains and upland forest**
  Adequate maintenance and protection of floodplains, dams, and river corridors is the most effective way to prevent future floods. Protection of these critical areas gives room for the water to spill over their banks when serious storms occur. Also, forested areas provide watershed benefits.

- **Adequate maintenance of building infrastructure**
  Standard design and maintenance of ditches and water control structures in building infrastructure is very vital to ensure an adequate channel of the water in the right direction without overflowing into houses and communities. Adoption of suspended pavement systems can create a strong substrate in these areas while allowing high-water absorption through their medium of uncompacted soil.

Implication to Architectural practice design

Professionals must be proactive in designing adaptive measures in order to cope if a flood occurs. The professional point of view in combating flooding is to create design measures in a situation where there is high demand for houses in the areas close to water. To address such a problem, the implementation of some design measures will be extremely beneficial. The need to introduce floating and amphibious housing designs in flood-prone areas is needed to reduce its effects on buildings and their users. An amphibious house is a building that rests on the ground, but whenever a flood occurs, the entire building rises up in its dock, buoyed by the floodwater.

It brings together standard components from the construction and marine industries to create an intelligent solution to flooding. Floating and amphibious houses are built to be located in a water body and are designed to adapt to rising and falling water levels. Floating houses are permanently in the water, while amphibious houses are situated above the water and are designed to float when the water level rises. Amphibious houses are usually attached to flexible mooring poles and sit on concrete foundations. If the water level rises, they can move upwards and float. The fastenings to the mooring post limit the motion caused by water. These types of houses are popular in highly populated areas where there is a high demand for houses near or on water. Floating and amphibious houses are very effective in dealing with floods because they adapt to rising water levels.

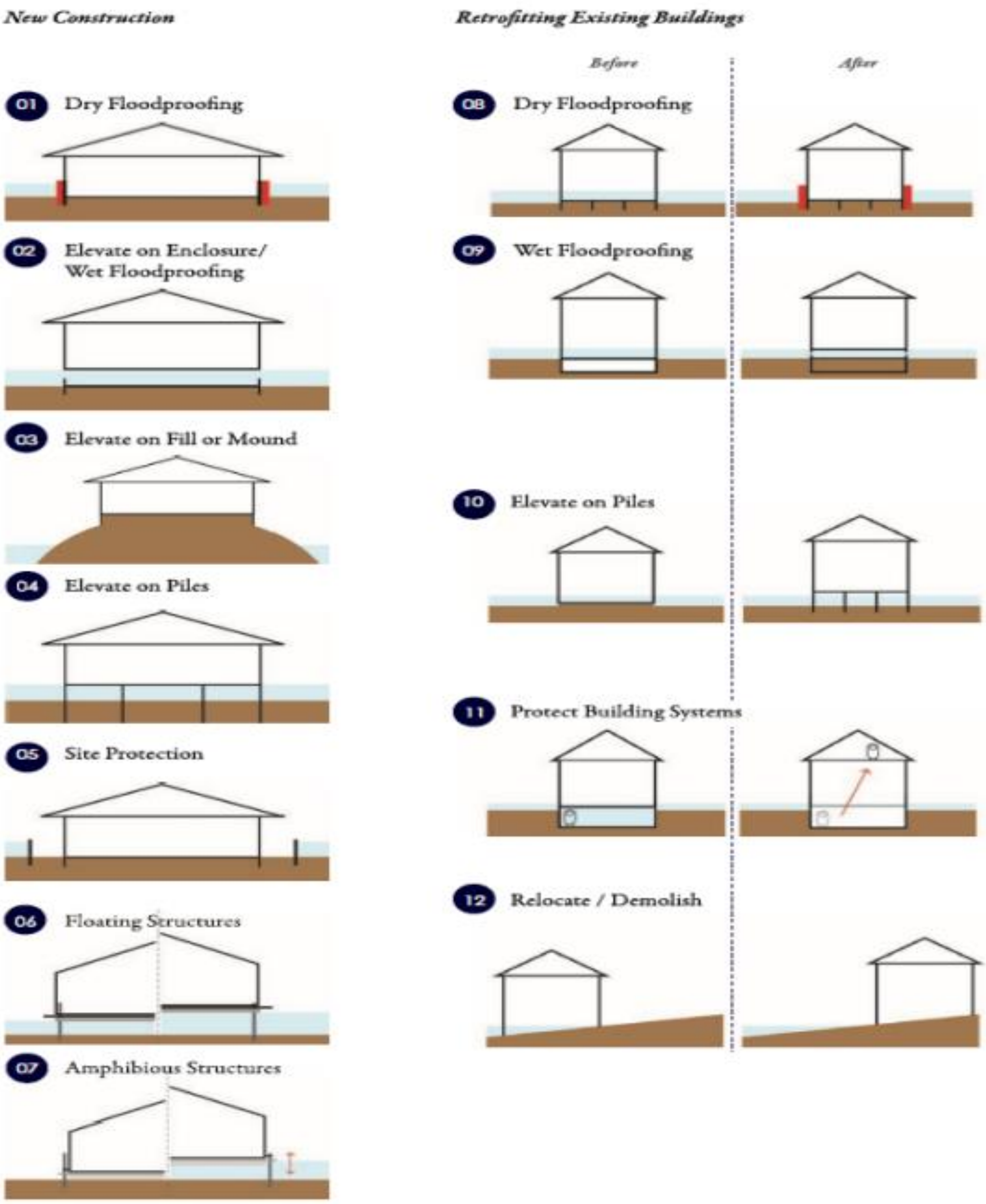

Figure 7. Resilient Adaptive Site Strategies, Source: (Burden 2013)

Conclusion

This paper investigated and identified the risk and resilience level of flood-prone areas within selected locations in Abuja, Nigeria as well as determined the flood resilient strategies that could be employed to mitigate flood risk to residential buildings. Results obtained show that there is an average percentage of residential areas that are affected by flooding in varying capacities. Further enquiry, however, goes to show that 48.9 percent of the sample population do not possess the knowledge of flood resilience within their buildings, while 12.0 percent are not sure. Among the 35.1 percent who know about flood resilience and its applications, only 25.3 percent agree that these measures have resulted in a reduction of damage due to flooding. The findings reveal that despite the average level of risk posed to residential areas, very much still needs to be done in order to educate the general populace on flood-resilient measures to be taken especially when building in flood prone areas. This paper further provides insight into steps which can be employed to raise awareness and implementation levels of flood resilience strategies. It contributes to the body of knowledge in such a way that it promotes the benefits of flood resilience in residential areas in Nigeria. Focus should be taken away from flood risk alone and redirected to flood resilience awareness. This would serve the proverbial purpose of "killing two birds with one stone" as it would enlighten the general populace on the varieties and benefits of resilience strategies while encouraging them to utilise them more, ultimately resulting in a safer residential environment.

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Conflict of Interests
The authors declare no conflict of interest.

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ORIGINAL ARTICLE **SOCIAL SCIENCE**

RELIGION AND DISASTER MANAGEMENT: A STUDY ON TWO SELECTED VILLAGES IN COASTAL BANGLADESH

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Abstract
Study on cultural elements to reduce vulnerability become so popular in academia. Therefore, over the past few decades, research on the understanding relationship between religion, as a cultural element, and disaster management has also gotten its popularities. Nevertheless, how different religious aspects can influence people to shape up their disaster management strategies remains untold. To address this gap, adopting a mixed-method approach of data collection this study selected two most disaster-prone areas namely, Dacope Upazila and Koyra Upazila, of Khulna District in Bangladesh to collect primary data. The findings of this study reveal that in some areas religious institutions play a significant role through disseminating disaster-related news, providing social supports immediately after a disaster, and acting as a victim support center. Similarly, religious masters as well as other religious leaders have played a leadership role to bind people together. The findings of this study also indicate that the most important role of religion in disaster management was psychological. Besides, religion increase the capacity of community management through enhancing moral responsibilities. However, the lack of coordination of these potential cultural elements remains unused in the field of disaster management. Therefore, through this study, the researcher would like to call upon policymakers' attention to integrating religious elements with other disaster risk reduction elements.

Keywords: Religion, disaster, risk reduction, coastal people, community, Bangladesh

Introduction

Religion, implies for belief in supernatural power, embedded with human culture from the history of human civilization. Similarly, natural calamities are another traditional affair that has been experienced by the human race over generations. Association between these two elements, nowadays, become a subject matter of social resilience assessment to do community-based disaster management. The importance of the study of the relationship between religion and disaster management has also been highlighted in the third priority of the Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030) where it has emphasized cultural resilience along with economic, social, and health resilience (Roy et al., 2022). Besides, SFDRR also has emphasized community participation through assessing community needs and priorities (Roy et al., 2023). In a direction with this view, this study was designed to understand how local communities manage different disasters with the help of religious codes and practices as a part of their culture.

Research in disaster management from the religious point of view is not new. Over the past few decades, several scholarly works have been found on this ground. Most of the literature has followed a normative approach rather descriptive manner. For example, most of the local people of coastal areas of Bangladesh have strongly believed that a disaster is an act of God evident by Garai (2017). Likewise, Call (2012) has revealed that the influence of religion makes people fatalistic. Since, during disaster people used to emphasize more on practicing religious

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activities instead of protecting their lives, and belief that through these activities, God could reduce the magnitude of disaster as well as protect them from the mass distraction (Call, 2012; Paulson & Menjivar, 2012). Paulson and Menjivar (2012) also expressed that during a disaster, these guys used to be busy worshiping many objects instead of saving themselves. Subsequently, loss of life and property had been increased (Call, 2012). Therefore, instead of advocating the importance of religion in disaster management, these scholars have recommended reducing the influence of religion in disaster management.

Unlike the above discussion, some scholars (i.e., Ensor, 2003; Ha, 2015; Hope & Jones, 2014; Roy et al., 2022;) have presented that faith in religious masters, as a key stakeholder, was another important role of religion which sometimes motivates and leads people not to adopt and welcome innovation regarding disaster management. Subsequently, superstition and false beliefs can be found in society. Sometimes, a subculture regarding these superstitions and false beliefs have been found in some community (Ensor, 2003; Ha, 2015; Hope & Jones, 2014; Yari et al., 2019). For instance, if the religious master remains pleased with them then God is also pleased with them (O'Connell, 2018).

Another way, common perception also found that disobeying a religious master's order or words means disobeying God's order (O'Connell, 2018). Moreover, a sense found by Gillard and Paton (1999), Hussain et al. (2014), and Call (2012) among local people is that this divine individual has the power to control natural disasters. Such political influence generally demotivates people to follow government initiatives. For instance, Garai (2017) has evidence that such pressure of religion on local people sometimes hamper governmental initiatives regarding disaster risk reduction interventions. Subsequently, ignoring the latest disaster management strategies and policies by the local people because of the over dominance of religious masters may arise a new subculture.

In a line with the above discussion and focusing on religious-based subculture some scholars like Dekens (2007), Bentzen (2013), Call (2012), Iloka (2016), Baytiyeh and Naja, (2016), Ibrahim et al. (2019) and Roy et al. (2020) have found loss of life and properties due to ignorance of early warning. However, none of them have mentioned whether the religious masters were the primary person who motivates them to ignore the early warning system. Most of them are partially or latently mentioned. Some of them have given a little hint. Like, Ibrahim et al. (2019) through a study in Southwestern Bangladesh have stated,

> …The research reveals that jerry-built roads, fear of theft, disbelief, and mistrust about warnings, lack of awareness about hazards, and the poor state of the cyclone shelters are the main reason for non-evacuation during cyclones. Besides, past experiences of warning failures, superstitious, religious beliefs, fatalism, safety issues for women also worked to influence people's decision to leave their houses during the warning periods… (p. 53)

Since no clear indication has been found regarding the influence of religious masters on local people associating disaster management, it is hard to draw a single conclusion without evidence. And beyond no doubt, the religious masters are the critical agents of religion so excluding them and their influence it would be difficult to understand the power of religion in disaster management. As very few studies have presented the role of religious masters in disaster management in a descriptive manner so this study will try to present the role of religious masters in disaster management with special reference to southwest coastal areas of Bangladesh.

Moreover, religious institutions along with religious codes and practices are other elements of the religion that bind people together and drive people to believe in supernatural power. According to this point of view, researchers like Aten et al. (2019), Biggs et al. (2017), Call (2012), Ha (2015), Grandjean et al. (2008), and Sheikhi et al. (2021) have demonstrated that religious institutions, practices, and codes have a major psychological impact on disaster management. For instance, Grandjean et al. (2008) have evidence that ancient religious myth was a psychological mechanism that led humans to find out supernatural explanations about disasters and faith in divine retribution. Emphasizing this point of view Dodds (2015) found a common explanation in each religion that a disaster is an 'Act of God' and it is a consequence of people's misdeed.

Similarly, such psychological understanding regarding the origin of disaster and the consequence of disaster was another attitude that grew from the influence of religion and prevent people from rational decision-making in a crisis moment like a cyclone. Another normative literature shows a negative relationship between religion and community adaptation capacity. Such as, the more religious person is less likely to prepare future adaptation mechanisms at both personal and community levels (Call, 2012). Though the above-discussed literature has presented some aspects of the relationship between religion and disaster management, most of them failed to draw a clear image regarding the power of religion in multiple phases of disaster management. More specifically, how local people used to do different religious activities in three phases (i.e., pre-disaster phase, during disaster phase, post-disaster phase) of disaster. Therefore, the key emphasis of this study is to present the local people's religious activities in three phases of a disaster. The significance of this study would be a guideline to the policymakers to take the necessary steps to design a resilient community-based disaster management program.

Specific Objective(s)

a. To understand the role of religious institutions in disaster management;
b. To present the religious master's role in disaster management and
c. To examine how does religion shape local people's coping strategy.

Role of Religious Institutions and Masters

The study on understanding the influence of religious institutions and religious masters on humans in a line with disaster management is not new. With the very begging of the twenty-first century, several scholars have paid attention to understanding the linkage between religion and disaster management. For instance, using content analysis Grandjean et al. (2008), Dodds (2015) and Aten et al. (2019) have found ancient religious myths had a psychological setup that helps individuals to believe in supernatural explanations, i.e., disasters are an act of God. Whereas, Mohit et al. (2013) and Sheikhi et al. (2021) have explored a significant role of 'Masjid' as a religious institution in disaster management. At the same time, some others also found a triangular relationship among humans, environment, and religion, where non-religious people had anxiety about religion to environmental issues compared to religious people (Hope & Jones, 2014). The same evidence was also found in another qualitative work of Ager et al. (2015) that local communities who have faith in religion had a vital role to promote resilience during a humanitarian crisis.

Similarly, some literature has presented that there has a mutual relationship between religious masters and disaster management in terms of minimization of vulnerability and increase of resilience in society since local people have deep faith in their words. For instance, Gillard and Paton (1999) and Hesse (2012) have presented that religious denominations have exercised a differential impact of different vulnerabilities. It has also been found that religious institution plays a specific role in a specific place. For example, a study by Paulson and Menjívar (2012) and Mallick et al. (2010) have found that religious institution-based relief had more value in India but low in America where groups and networks had played a good value.

The same evidence was also found in the study of Ha (2015) in Korea that religious institutions influenced building resilience in local communities. Another study in Indonesia quantified that in disaster-prone areas people are more religious rather than in normal areas (Bentzen, 2013). But Call (2012) proved that in Indonesia more religious persons are less likely to prepare for future adaptation, besides he also found a negative relationship on religious belief in urban and rural differences. However, above all studies indicate a particular role of religious masters and institutions associating disaster management. But, at the same time, a clear literature gap has also been visible that very few studies have shown how religion governs the behavior of coastal people of Bangladesh in terms of Disaster Management. Therefore, the novel contribution of this study would be how local people used motivated by religious institutions and religious masters to shape up their disaster management activities.

Sources of Faith

It is quite common that natural disaster is a natural consequence. But from the religious point of view natural disaster is controlled by supernatural power. However, to understand the power of religion in disaster management it is important to understand the elements that make individuals believe in supernatural objects. In this section of this study, the researchers have reviewed some of the religious documents which can call as evidence and used by religious masters to access their power. In a line with this perception, some scholars believed that over some time people observed that natural disaster remains beyond human control, and so, people believe disaster is an "Act of God" (Dodds, 2015; Furedi, 2007; Yamada, 1981).

Moreover, according to the religious code, God or the supernatural power have created us for some unknown purposes and humans should better seek the purpose and complete it. Hence, a pious person believes if we forget this and disobey the holy order God uses the disaster to control us (Sony and Roy, 2019; Aksa, 2020). The root of this faith is found in the sacred books which are followed by religious institutions and taught by religious masters to the common people. Some important holy books quotations related to the disaster have been enlisted in this section. For instance, Allah Subhanahu WaTaala (SWT) says in the Holy Quran,

> And whatever of misfortune befalls you, it is because of what your hands have earned. And He pardons much (The Al-Quran, Sura, Ash-Shura 42:30).
>
> And fear the Fitnah (affliction and trial, etc.) which affects not in particular (only) those of you who do wrong (but it may afflict all the good and the bad people), and know that Allah is Severe in punishment (The Al-Quran, Sura, Al-Anfal 8:25).
>
> Evil (sins and disobedience of Allah etc.) has appeared on land and sea because of what the hands of men have earned (by oppression and evil deeds, etc.), that Allah may make them taste a part of that which they have done, in order that they may return (by repenting to Allah, and begging His Pardon) (The Al-Quran, Sura, Ar-Rum 30:41).
>
> And if the people of the towns had believed and had the Taqwâ (piety), certainly We should have opened for them blessings from the heaven and the earth, but they belied (the Messengers). So, we took them (with punishment) for what they used to earn (polytheism and crimes, etc.) (The Al-Quran, Sura, Al-A'raf 7:96).

Similarly, in the holy Bible about 100 verses found about natural disaster. For instance,

> I form light and create darkness, I make well-being and create calamity, I am the Lord, who does all these things (The holy Bible, Isaiah 45:7).
>
> There will be great earthquakes, and in various places famines and pestilences. And there will be terrors and great signs from heaven (The holy Bible, Luke 21:11).

Even some quotes also found in Hinduism which supports these people's source of believe of disaster as a supernatural act. For example,

> The whole cosmic order is under me. Under my will it is automatically manifested again and again, and under my will it is annihilated at the end (Bhagavad Gita, Chapter 9:8).
>
> If you become conscious of Me, you will pass over all the obstacles of conditioned life by My grace. If, however, you do not work in such consciousness but act through false ego, not hearing Me, you will be lost (Bhagavad Gita, Chapter 18:58).

Besides, few sacred tales also bear the evidence of great disaster. For example, the great flood's background and description found, along with another sacred book, in Sura 11 (Hud) and 71(Nuh) of the Holy Quran, in Genesis 6:9-9:17 of the Holy Bible. Some points are attached below,

> [11.37] And make the ark before Our eyes and according to Our revelation, and do not speak to Me in respect of those who are unjust; surely, they shall be drowned. [11.38] And he began to make the ark; and whenever the chiefs from among his people passed by him, they laughed at him. He said: "If you laugh at us, surely we too laugh at you as you laugh at us". [11.39] So shall you know who it is on whom will come a chastisement which will disgrace him, and on whom will be lasting chastisement come down. [11.40] Until when Our command came and water came forth from the valley, we said: "Carry in it two of all things, a pair, and your own family – except those against whom the word has already gone forth, and those who believe (The Al-Quran, Sura, Hud 11:37-40).
>
> [71.21] Nuh said: "My Lord! Surely, they have disobeyed me and followed him whose wealth and children have added to him nothing but loss. [71.22] And they have planned a very great plan. [71.23] And they say: 'By no means leave your gods, nor leave Wadd, nor Suwa; nor Yaghus, and Yauq and Nasr. [71.24] And indeed they have led astray many, and do not increase the unjust in aught but error.' [71.25] Because of their wrongs they were drowned, then made to enter fire, so they did not find any helpers besides Allah. And there believed not with him but a few. [11.41] And he said: "Embark in it, in the name of Allah be its sailing and its anchoring; most surely my Lord is Forgiving, Merciful (The Al-Quran, Sura, Nuh 11:37-40).
>
> The flood continued forty days on the earth. The waters increased and bore up the ark, and it rose high above the earth. The waters prevailed and increased greatly on the earth, and the ark floated on the face of the waters. And the waters prevailed so mightily on the earth that all the high mountains under the whole heaven were covered. The waters prevailed above the mountains, covering them fifteen cubits deep (The Holy Bible, Genesis 7:17-20).

The study of Sony and Roy (2019) mentioned that the sacred story of great floods is also found in Hindu mythology in different forms. The story-like, "one day the tenth 'Manu' caught a small fish. Surprisingly, the fish spoke to him and promised to protect him from the coming deluge. Manu put the fish in a small water-filled container and fed it. The fish grew by leaps and bounds and Manu kept transferring it to larger and larger containers. It grew to immense size and told him to build a big boat and tie it to the fin of the fish and sail towards the northern mountain. The great flood came and it was relentless and the fish which was Vishnu's Matsya Avatar saved humanity from extinction" (Augustyn et al., 1998; Bhatt, 2006). The above message makes some value among people about a natural disaster (Sony & Roy, 2019). So, it is clear that the source of the faith of religion on disaster is embedded with its origins as well as the holy books.

Materials and Method

Background of the Study Area

To meet the current study's objective two most disaster-prone southwest coastal areas i.e., Koyra 5 no. village and Koyra 6 no. village of Koyra Union under Koyra Upazila and Kailashgonj village and Ramnagar village of Kailashgonj Union of Dacope Upazila of Khulna district in Bangladesh have selected purposively as a study area. The following maps were identifying the locality of the study area (Figure 1). Along with other southwest coastal areas, these two areas have been experiencing frequent natural calamities each year (Saha, 2017).

The socio-cultural background of the population was another motivation that has assisted the researchers to select these study areas. For instance, about 96.9% of respondents of the study area were found who have claimed that they have deep faith in religion and used to follow religious code and practice in most aspects of their daily life. In addition, it also found that about 76.1% of respondents had been used to doing their prayer once a day.

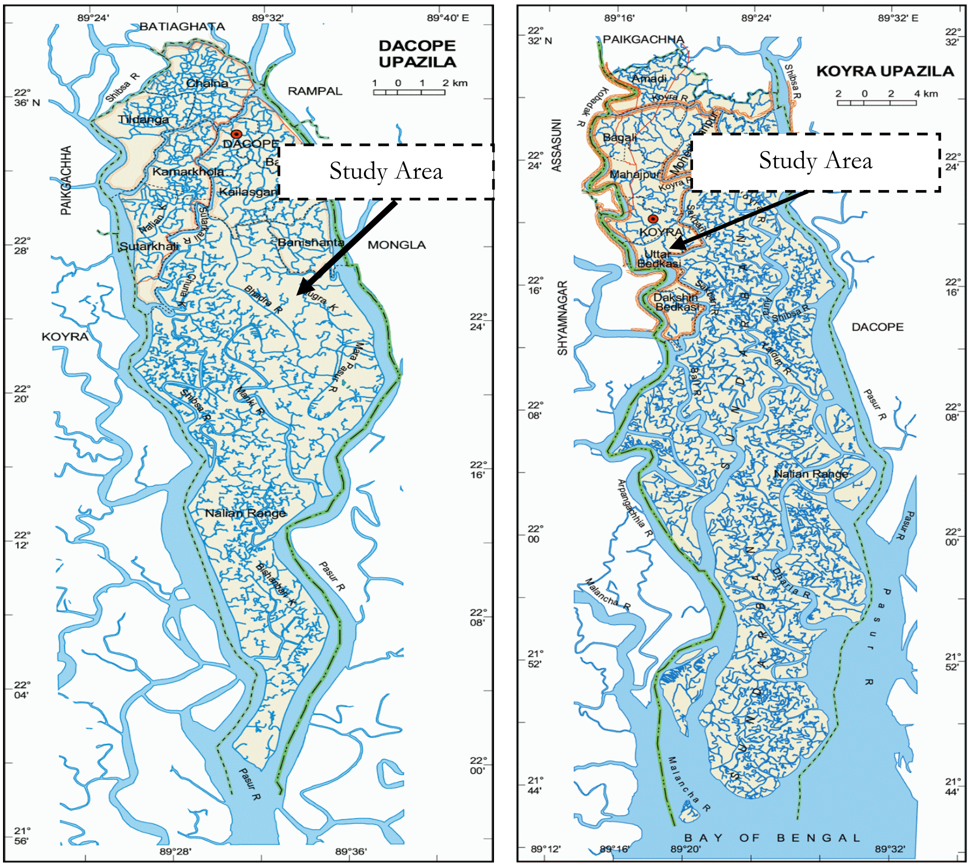

Figure 1. Maps of Dacope Upazila and Koyra Upazila (Local Government Engineering Department, 2018).

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Study Design

This study had used both qualitative and quantitative approaches and was descriptive. This current study was dealing with some qualitative variables like religion, disaster management, and so on. Therefore, to understand the existing scenario the researchers adopted qualitative tools to capture respondents' perceptions, feelings, and emotions to meet the objectives. The qualitative section with a semi-structured interview schedule (see Appendix I-III), as well as interview guidelines, were used for the in-depth interview (IDIs), focus group discussion (FGD), key informant interview (KII) to accumulate in-depth data.

Further, to know the majority view regarding the objectives of the study the researchers have also conducted a social survey with a questionnaire. The purpose of this two-phase, descriptive mixed-methods study was to obtain in-depth information and understand how many people hold similar points of view. The unit of analysis of this study was those people who have been living in the study area for the past twenty years and experienced serious natural disasters like the super cyclone Aila in 2009. For KIIs respondents, the religious masters have given special priorities, especially those who have been staying in the study area for the past twenty years.

Data collection procedure

The whole data collection process has been divided into two phases. At the beginning of the first phase, quantitative research questions (see Appendix IV) have used to indicate the relationship or comparison of the independent and dependent variables with participants at the research site. Through purposive sampling eight FGDs (two per village and four for male and four for female, N=25), six KIIs (three per religion), and eight IDIs have been conducted to attain the study objectives. Along with a checklist and an FGD guideline and a recorder, the primary investigator and his two note-takers have collected the qualitative data between November 2019 and April 2020. Though the checklist has been prepared in English, during data collection the conversation has to happen in a local language like Bengali to gather local respondents' perceptions and feelings regarding the study objective. Initial notes have also been taken in the local language.

In the second phase, this study has been used quantitative data to justify qualitative data to present the findings more accurately and the study objectives more logically. The number of households of Kailashgonj union of Dacope Upazilla was 3443 and the Koyra union of Koyra Upazilla is 7788 (Bangladesh Bureau of Statistics, 2014). By using an online sampling calculator with 4.5 confidence intervals and using simple random sampling 455 samples have been chosen to collect quantitative data. Again, two-third of the total sample have been distributed in Koyra union (Koyra 5no. village= 151 and Koyra 6no. village= 152) as it held a higher population size and one-third of the total sample have been distributed in Kailashgonj union (Kailashgonj village= 75 and Ramnagar village= 76). The mean age of the respondents was 46 years old (*SD* 13.5). Besides, 75 percent of respondents were Santayana religious believers, and the rests of the respondents were Muslims. The mean family members of the respondents were about 5 (*SD* 1.5) and the average year of schooling was 7.44 (*SD* 3.5). Besides, the average income of the respondents was BDT 14,241/=, and the mean savings of the respondents was BDT 1,494/=. Most 67% of respondents' housing structure was Kacha, which floors were made of mud and the wall was made of bamboo and tin, and the roof was made of tin.

Moreover, data about respective concepts have been collected by incorporating relevant items in the structured and semi-structured interview schedule and analyzed to comprehend the objectives of the study. This survey has conducted between May 2020 and January 2021. To collect survey data a group of data collectors has been hired from the study areas who were tertiary level students. All data collectors have received two days of training on data collection procedures and ensure ethical stands. Like the qualitative phase, the survey questioner has been prepared in English but during the data collection, the data collectors have asked the questions in their local language.

Instruments

To know the role of religion in disaster management, each of the questions from the checklist, FDG guideline, and questionnaire have been prepared with key emphasis to three-phase of disaster management, i.e., pre-disaster, during the disaster, and post-disaster phase. The role of religious institutions in disaster management has been captured via asking the religious institutional role and activities during a disaster, pre-disaster, and post-disaster phases in the study area. The religious master's role in disaster management has been revealed through religious master's activities in the three-phase of disaster management and particularly the KII and IDI were used to accumulate these religions' specific information. To examine how religion shapes local people's coping strategies. The researcher has tried to capture respondents' perceptions about religion-based financial aid, early warning, and other coping strategies.

Data analysis and presentation

Though the accumulations of qualitative data through FGD, KII, and IDIs have happened in the local language the transcription has been made in English. The researchers have paid special attention during translation between Bengali and English. After the transcription, the principal investigator along with his research assistants have categorized the responses and identified the quotes relevant to research objectives. The whole quotes have been presented in this study under three sub-headings according to the research objectives. Saturated codes have been separated and exceptional codes along with mostly mentioned quotations have been included in the findings section to conclude. Similarly, though survey data have been collected in the local language the data entry in the IBM SPSS, the popular statistic software has been done in English. In the quantitative analysis, only descriptive analysis has been done to support the qualitative data.

Ethical Consideration

The study was consistent with the principles concerning human research ethics of the Declaration of Helsinki (World Medical Association, 2013), as well as following the guidelines for the responsible conduct of research of the Finnish Advisory Board on Research Integrity (2012). It was fully ensured the anonymity and confidentiality of the respondents. Respondents have been informed about the purpose and type of the study as well as their participation in the study will be voluntary.

Findings

According to the objectives of this study, the findings have been organized under three subheadings respectively, the role of religious institutions in disaster management, the religious master's role in disaster management, and local people's coping strategy from the religious point of view. The first section (sub-heading) has presented the different religious institutional role in the three-phase of disaster management. The next sub-heading has discussed religious masters as well as leaders' role in three phases (pre, during, and post) of disaster management. The last sub-heading of this study has discussed the overall local disaster coping mechanisms concentrating on the religious viewpoint.

The role of religious institutions in disaster management

According to the findings of this study, there were two types of religious institutions in the study areas. The first one was traditional religious institutions like temples, mosques and the second one was religion-based associations. The findings of these studies indicate that during a disaster both of these institutions have played some specific role such as disseminating disaster-related news, acting as a primary support center, and a place of social integration.

Disseminating disaster related news

Firstly, disseminating disaster-related news which includes an early warning, emergency preparation, emergency responses, and so on. Through this study, it has been found that very few (7%) respondents have received disaster-related news from religious institutions (Figure 2). In an in-depth interview, a respondent emphasized that,

> I am sure, before the Aila, I have heard that some young people were calling us to take shelter on the embankment through using the mosques' mike. (Nomita Roy[1], 52 years, IDI-5, Dacope)

Similarly, another respondent said that,

> The mosque has conveyed disaster news to us and the Imam (the religious leader) have encouraged us to take shelter in the cyclone shelter through mike. (Nibedita, 34 years, FGD-01, Koyra)

[1] Pseudonyms have used throughout the paper.

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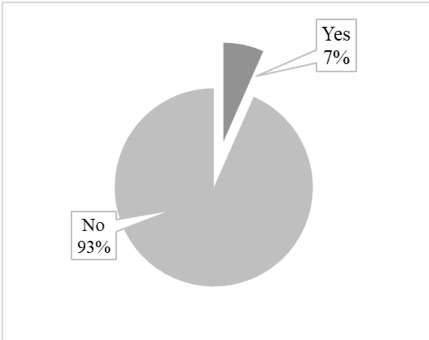

Figure 2. Percentage of respondents' opinion on religious institution providing them disaster news. (Field survey, 2020-2021)

However, the findings of this study revealed that most (93%) of the respondents did not receive any disaster-related news from religious institutions (Figure 2). On this point, a respondent uttered that,

> Our mosque's infrastructure is not good. Though we have two mikes but lack of electricity maximum time it was remained unused. And our hujur's (religious leader) hometown is far away from this area. Since he did not know much about the nature of disasters in this area, he failed to aware us. Interesting matter was that, we had come forward to assist him, during the Aila (2009). (Rafique, 63 years, IDI-03, Koyra)

Supporting others on this point a respondent mentioned that,

> I think, not only me but also other people in this area ever get any kind of disaster related information from our religious institutions. I don't know how religious institution can provide disaster related information. I think it is government's responsibility. (Sujit Mondal, 58 years, IDI-7, Dacope)

Through this study, it has been found that different factors have influenced religious institutions to disseminate disaster-related news to local people from religious institutions. For instance, religious master's disaster-related knowledge and previous experience, residential location, and availability of resources like electricity to run mike.

Religious institution as a support center

Another role of the religious institution has found through this study was the disaster-related aid support which comes in the form of pure drinking water (2.9%), foods and clothes (58.9%), cash (15.4%), only food (22%), and undefined humanitarian support (0.9%) (Figure 3). From figure 3, it is also clear that among all these aids, mostly cooked food and drinking water was very common. On this point, a respondent mentioned that,

> There is a deep tub-well in the mosque and many villagers used this water for drinking purpose. During Aila (2009) these tub-well was the primary source of drinking water of our neighboring areas. (Abul-Basar, 63 years, FGD-2, Dacope)

Similarly, another respondent said that,

> Our temple has gotten about 1-ton rice and wheat from the government after Aila (2009). It also got cash from government which allocated to the poor people and the also for its infrastructural development. We have received some. Our neighbors also received some relief from those funds. (Momota Rani Mondal, 24 years, FGD-3, Dacope)

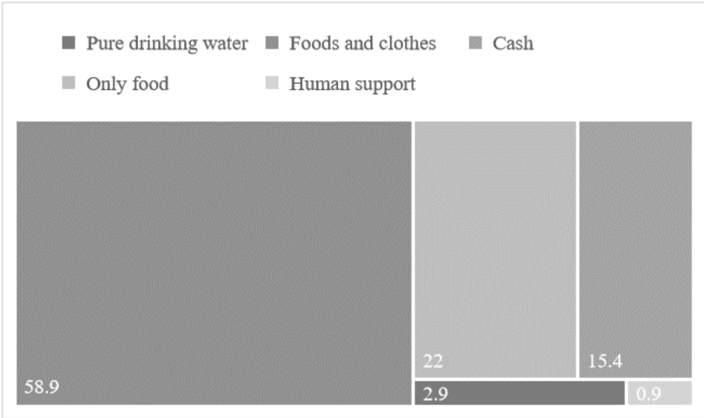

Figure 3. Percentage of different type of supports received by the respondents from the religious institutions. (Field survey, 2020-2021)

Likewise, a respondent mentioned that,

> …After natural disaster, I have seen, they [religious institutions] in our area providing support such as foods, clothes etc. Though I don't expect any support from them, because of their unequal distributions, which is not enough according to the demands but these institutions try their level best to help the disaster affected people… The religious institutions generally get financial aid from government, political leaders, and collection from general people. (Heron Kumar Da, 52 years, IDI-01, Koyra)

Moreover, this study found that, in some area people have used their religious institution as a cyclone shelter. Here, most of the respondent at social survey agreed that there was no religious barrier to take shelter in a religious institution during a disaster (Figure 4). On this point a respondent said,

> During Aila (2009), I have taken shelter to my nearest mosques… there was no barrier to take shelter on the mosque in our area because all religion promotes humanity not cruelty. (Khairul Shikdar, 55 years, FGD-06, Koyra)

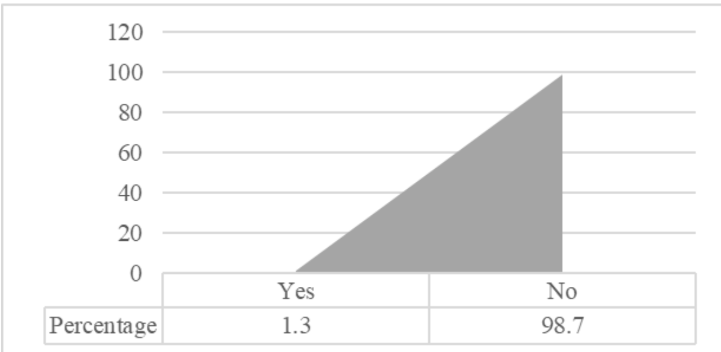

Figure 4. Percentage distribution of responses on religious barrier during taking cyclone shelter in a religious institution. (Field survey, 2020-2021)

Unlike them, another group of respondents also found who have not received any notable aid from the religious institution. Durga Vaskor Roy, a 78 years old 2nd IDI respondent who lives in Koyra, stated that religious institutions do not play any significant support during any disaster except some early warning. Similarly, a FGD respondent said that,

> No relief has come from any mosque or temple rather than the villager's collect money from the village to reconstruct the mosque. (Aklima, 32 years, FGD-1, Koyra)

Howsoever, most of the respondents did not receive any financial aid from the temple and mosques in the study area. The respondents have not perceived that it was religious institutions duty to provide their any relief during or after a disaster. On this point a respondent mentioned that,

> The religious institution did not provide any financial or another support to the disaster affected people because it had no sufficient resource moreover it also depends on the help of others. (Motiar Rahman, 55 years, KII-1, Koyra)

Another respondent mentioned that,

> …I do not get any support from temple/ mosque. Additionally, I don't get any basic requirements from religious institutions after facing any sever disaster. But my expectation is that the person who lost his/her home at least they deserve some instant help from religious institutions after occurring disaster, since generally we all provide different support to these institutions. And they always have some fund which should have spent for human kind. (Anila, 50 years, IDI-08, Dacope)

Among all the respondents, some respondent (6%) mentioned that instead of religious institution there were a religious association in the study area via which they used to support disaster affected vulnerable people. One of the members have said that,

> We had a religious organization named "Natonarayan Mandir Sangathon". In this organization we meet together three to four times in a year to make fund and decision. This organization tries to find out the old and disable people during the disaster and search the house having little food and water to supply them dry food, water and basic Medicare. (Plabon Roy, 32 years, KII-3, Dacope)

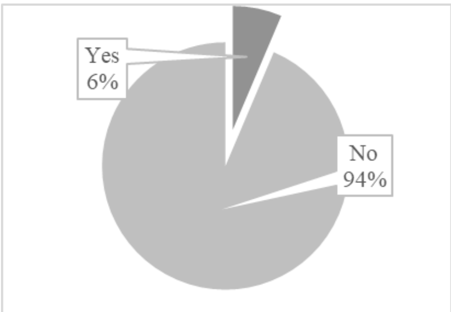

Figure 5. Percentage of respondents who have received some relief from a religion-based association in the study area. (Field survey, 2020-2021)

The findings of this study have revealed that religious institutions as a social support plays a significant role in mostly post disaster phase. This institution plays a symbol, based on which one group of people deliver different social supports and the other group used to receive it.

Social integration role of religious institution

Through the social survey most of the respondent (89.2%) negatively responded on social integration role of the religious institution whereas only 10.3% respondents have agreed positively (Figure 6). From their perception religion has an active role in bringing people together which helps to cope with disasters. For instance,

> I think that the religious activities have impact on community integration. Because religion teaches us to be assembled with community and mankind is a great virtue. The religious value encourages rich people to assist poor people such motivation can make an equilibrium in our society…such values drive people to assist one another even in the crisis moment. (Abul-Basar, 63 years, KII-2, Koyra)

Similar views also found in another respondent's opinion,

> …Religion helps us to be assembled with community and overcome critical situation collectively. (Heron, 35 years, FGD-02, Dacope)

Another respondent mentioned that,

> Through day-to-day worship program, people used to gather in one place and exchange their feelings. Take care of each other which lead them to be intimated with each other…especially in the Friday most of the Muslim people along with the children assemble together to pray... similarly I have also seen the Santayana religious people in our community worship together…. In such manner the community bonding used to increase which may help people any crisis moment. (Mr. Washim, 52 years, KII-4, Dacope)

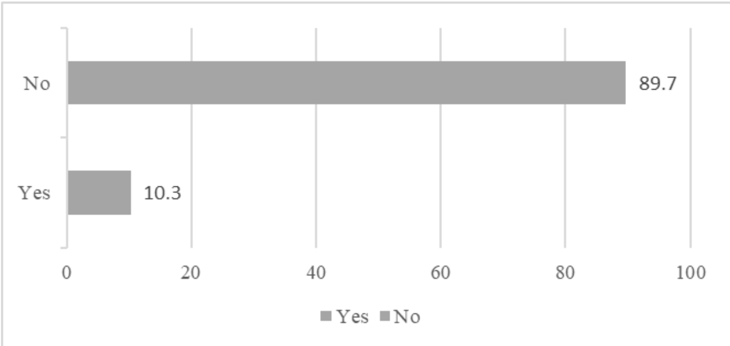

Figure 6. Percentage distribution of respondents about social integration role of religious institution. (Field survey, 2020-2021).

In term of social integration role this study found two perceptions from two group of people. One the one hand, one group of people who did not believed that religious institution has a significant role in social integration during disaster which is very important to do resilient local communities. On the other hand, another group of respondents who were mostly religious masters as well as leaders strongly believed there were a special role of religious institution to increase social integration in local communities.

Role of religious master's in disaster management

The findings of first phase of this study present that in the study area the religious master's used to play multidimensional role in disaster management. Notwithstanding that at the second phase it was found that most of the respondents (87.5%) have responded negatively about the role of religious master in disaster management (Figure 7).

However, through first phase it was found that raising awareness was very common role that highlighted by most of the respondents which also supported by 12.5% respondent in the second phase. One of the specific points was that some religious masters in the study area were also member of the village disaster response committee. On this point a respondent mentioned that,

> The Imam Shaheb (Muslim religious master) of our area used encourages, and motivate the general people to hold their confidence during any disaster. Each weekend he also gives some speech focusing on disaster related preparation. As a Moajjin (assistant of the religious master), I used to provide the disaster news to the villagers through the mike of the mosque. (Abul-Basar, 63 years, KII-2, Koyra)

Similarly, another respondent said that,

> Our Thakur (Santayana religious master), used to convey disaster news and motivate us not to do immoral activities. Thus, we can save ourselves from the disaster…the Thakur used to take incentive after finishing worship. (Momota, 36 years, IDI-04, Koyra)

Sometimes, instead of religious masters some religious leaders used to come forward to assist the vulnerable people. On this point a respondent mentioned that,

> Before any natural disaster, the members of our association, Natonarayan Mandir Sangathon, come forward to warn people and raise awareness among the people. Take people to the cyclone shelter. Reconstruct the embankment and houses… During Aila (2009) our organization have raised handsome amount of fund through using our personal link and constructed 100 cyclone resistant houses in our area. (Plabon Roy, 32 years, KII-3, Dacope)

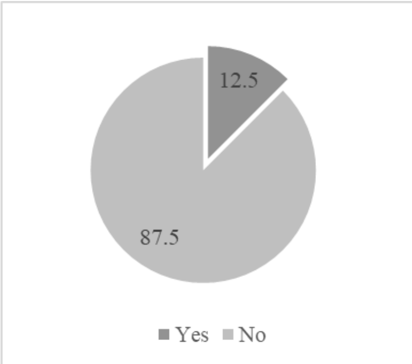

Figure 7. Percentage distribution of respondents' opinion on role of religious masters in disaster management. (Field survey, 2020-2021)

Likewise, through this study the leadership role of religious masters also found. For instance, Mr. Washim, 52 years old religious master and 4th KII respondent, have mentioned that he used to try to integrate the community people to combat a disaster collectively. Though they did not work organizationally, they have tried to support the poor people as much as they can. On this point a respondent elaborated that,

> In our area, most of the time our *Imam Shaheb* lead and motivate us to involve various social services. Like, last year we have involved in reconstruct two vulnerable people houses. Each of our community members has taken part to these activities. Some have given money and some have given labor. And this way the poor family's vulnerability has been minimized. (Atikur, 57 years, IDI-06, Dacope)

On the same point another respondent stated that,

> People used to obey religious masters without any questions. So, a religious master can use these people in different ways under their leadership social reconstruction and inter-personal communication can be build and rebuild which can be helpful during any disaster. (Nomita Roy, 52 years, IDI-5, Dacope)

Moreover, providing psychological support by the religious masters was another notable role found in this study.

> Religious leaders encourage us to faith in God as he [Almighty] will save us from the disaster. At first, I consider same things after getting disaster news from any source; these are making consciousness, creating mass awareness etc. Such psychological support generally creates a hope among the people. (Heron Kumar, 52 years, IDI-01, Koyra)

However, the findings of this study also reveal that in some areas the religious masters did not do any significant contribution not only the disaster management but also to community members. For instance, conceding other FGD members, a respondent has argued that,

> The *Imam Sahheb* in our village did not play any significant role in disaster management. They did not try to aware people, confront disaster news, and help others perhaps, they eventually did not consider anything for the helpless which they could do without any difficulties. Even they have forced people to reconstruct mosques with the help of relief funds which is purely unethical. (Mr. Rahman, 55 years, FGD-03, Koyra)

Similarly, conceding other Mrs. Anila, 50 years of 7th FGD member of Dacope have said that the religious leaders have hardly contribution to help them during a disaster. Religious leaders don't motivate or integrate the community people to combat a disaster collectively during disaster. According to her, the religious masters as well as leaders only busy at taking care of themselves and their needs. Nevertheless, the contribution of religious masters in different phase of disaster management cannot be ignored. The findings of this study indicate that based on religious master's experience and knowledge they used to exercise their power in any crisis moment.

Local people's coping strategy from religious point of view

Pattern of belief toward natural disaster

Human perceptions in any events are different from one another. Toward natural disaster, it also differs from each other. In a line with this view, the findings of this study show that some respondents considered disaster as a curse of the God for their wrong deeds. For instance, one respondent mentioned,

> It is known to all that Allah used to control the natural disaster. In order to keep people in right path, the natural disasters are happening in different time. In our holly book we also found it. When we do not lead our life according to religious code of conduct and frequently violate the religious norms, natural disaster came from God as his order to punish the people. (Ashikur Rahman, 55 years, FGD-04, Dacope)

Similarly, another participant stated that,

> …The Cyclone Aila (2009) was a consequence of our mal-activities…before Aila people forget about the God and involved different harmful activities to the society and so to do check and balance Almighty given this disaster to us. (Abul-Basar, 63 years, FGD-08, Koyra)

Supporting above a religious leader has stated that,

> Religion is useful for disaster management. Religious activities such as praying, reciting holly books are helpful to reduce stress of the believers during disaster. (Mr. Washim, 52 years, KII-4, Dacope)

The findings of this study also present that after a tremendous natural calamity, the religiousness among the common people used to increase. For instance, a respondent mentioned,

> Previously, I did not perform religious function like prayer regularly, but after Aila, I am performing religious activities regularly. Now, I am a Moajjin (assistant of religious master) of my village mosque. (Motiar Rahman, 55 years, KII-1, Koyra)

In a line with this view, the findings of this study indicate that in some study area the community used to organize collective worship to protect them from any natural hazard. On this point a respondent mentioned that,

> To control disaster, the villagers organize collective worshipping ceremony and try to make the Thakur (God) pleased. Thus, minimum extreme natural events can take place in our area. After Aila (2009) you can see none of such extreme calamities happened in this area. I think Thakur pleased on us. (Pakhi Ghosh, 24 years, FGD-07, Koyra)

Role of holy books on local coping mechanism

The findings of this study also present that most of the respondents believing pattern regarding disaster used to shaped by the holy books. Most of the respondents (82.2%) used to believe such activities generally assist them to remain calm during any crisis moment (Figure 8). For instance, a respondent said that,

> After reading my religious books (Santayana religion), I have come to know that all disaster is controlled by specific god and goddess. If I can make them happy through honest worship. Then, to some extent, I will be safe. (Prya, 27 years, FGD-05, Dacope)

Supporting Pray another member of same FGD utter that,

> I believe God himself enforce the disaster to control the creation and God stop the disaster after showing his power. I depict 'when we pray to God during disaster, it is true that the losses of the disaster become low'. I believed the God Mohadev (God of Hindu religion) who control the disaster and I believed only Mohadev can keep us safe from the disaster. Because I am also read it in our holy books and all verses in the holy book have said by the God himself. (Simato, 31 years, FGD-05, Dacope)

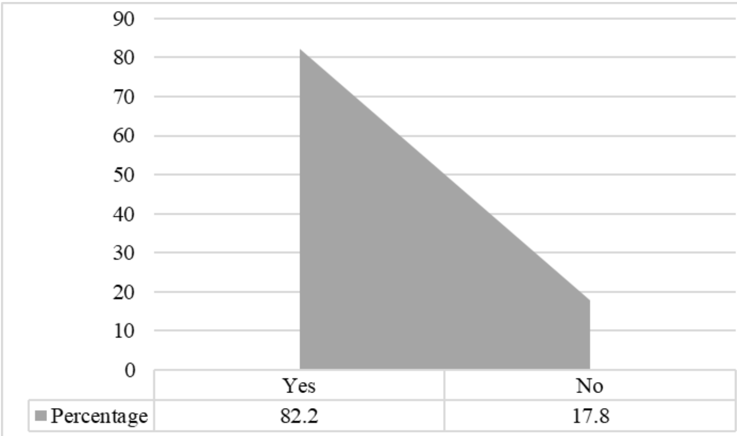

Figure 8. Percentage distribution of respondents who believed religious code can reduce their mental stress during any crisis moment. (Field survey, 2020-2021)

Similarly, another respondent mention that,

> Natural disaster given by the god and the human and the creature are also saved by God from disaster and human being has no control over it. (Rafique, 63 years, IDI-03, Koyra)

The holy books as a religious symbol placed a special role in disaster management. The findings of this study show that, during a disaster female respondent both in Santayana and Islam religion used to recite holy book. For example, Rohima Begum, 41 years old, FGD respondent of Dacope said that she strongly believes that holly book alleviates mental tensions in a disaster. From her faith on God, during Aila (2009) she used to recite her religious holy book again and again. And she believed that her losses in the super cyclone was minimum compare to others. Similarly, another FGD respondent said that,

> During Aila (2009), I had used to recite Ramayon. And I found my house safe and sound when I came from the cyclone shelter. (Subita, 39 years, FGD-03, Koyra)

Besides this, most of the respondents feel calm and confident through reciting holy books during any natural events. In a line with this perception Karim Sheikh, 67 years old FGD respondent of Koyra, added that reading holly book could reducing his pain. According to him this is the "Liberation in faith" which he meant the power of believe. He also added that his religious practices make him confident. From his point of view, most of the community members did not perform any activities to increase his confidence for disaster management. He has believed that such positive attitude is necessary to manage any disaster.

Social supportive role of religion in disaster management

The findings of this study show that religion usually encourages people to support others and such social supports can contribute a lot in any disaster management. On this point a respondent expressed,

> I believe during disaster, helping the helpless people means helping the God and God becomes pleased and it is considered as a great chance to come closer to the God. I believe during the disaster, to become stress free pray to God is a mandatory task. (Mr. Shobuj Ahmed, 32 years, FGD-06, Koyra)

For reducing disaster risk, many religious activities are also seen in this area which is helpful to increase social solidarity among the community people. Religious activities and practice differ from religion to religion. In Muslim religion milad-mahfil (a religious concert) and so on were arranged whereas, in Santayana religion, they recite Hary Krishno, Hara Krishna, Krisshna, Krishana Hary Hary (one of god's name in Santayana religion) or different types of religious doctrine One of the respondents explain that,

> We arrange milad and doa-mahfil (Muslim religious program) to make our god happy. We pray help to Allah during this activity. Through this collective actions Allah may please on us. (Abul-Basar, 55 years, FGD-07, Dacope)

Another participant belongs to Santayana religion stated that,

> Montro (specific religious quote), Jogya (Specific religious activities), Kalipuja (Worship to Goddess Kali), Monasapuja (worship of snake goddess), giving vog (sacrifice food) to the river are the religious activities we used to perform during a disaster. (Putul Rai, 24 years, FGD-01, Dacope)

Likewise, another respondent mentioned that,

> …When cyclone happened, I call Gangadebi (river Goddess) and worship to the Pabandebota (air God). I also called Ramshita (God and Goddess) …which make me mentally strong and reducing disaster loss. (Biswnapada, 40 years, FGD-08, Koyra)

Role of religious symbol in disaster management

The findings of this study show that different religious symbols have been worshiped by most of the respondents of this study. Though people of the study area were not aware about the significance of these symbols in disaster management, during disaster it has evident that these religious objects have protected life and property. For instance,

> There is a banyan tree beside my tea stall. There is also a stone under the base of the banyan tree. People from different village come here and keep money, sugar, milk and so on to keep happy of their god. However, during Aila (2009) because of this tree in this side the embankment has not broken and the houses were safe. (Rafique Talukdar, 63 years, IDI-03, Koyra)

Likewise, some people used to recite some specific religious quotation to them from a natural event. Motiar Rahman, 55 years old 1st KII respondent of Koyra, said that,

> I used to recite darudsharif in the time of disaster. I don't know if it is useful or not but it gives me intensive mental strength. (Motiar Rahman, 55 years, KII-1, Koyra)

Similarly, one of the respondents said,

> I usually recite doa Younus during disaster. I learnt it from our Imam Shaheb. Besides it, I also recite Azan during a natural disaster which I learnt from my grandfather. I think it works well. (Atikur Rahman, 57 years, IDI-06, Dacope)

The finding of this study also shows that, sometimes respondents used to vest themselves to the god and believed that in such manner they can save their family members. On this point a respondent mentioned that,

> During Aila (2009), I was remembering the name of mu almighty and praying to almighty frequently. I have prayed like "Hey God! I am offering my life to your hand; it's your time to save me and my surroundings. (Durga Vaskor Roy, 78 years, IDI-02 Dacope)

Through the social survey it was also found that about half of the respondents have supported such perception in the study area (Figure 9). Some respondents of this study, like Anila, believed that disaster make their faith on religion strong. She expressed as,

> …But my religious knowledge might help me control disasters such as before occurring disaster I am praying much more than the normal situation such as call the Almighty repeatedly and again as well as read the holy book "Geeta". Even after just getting knows about the disaster, at first calls my almighty to save my life. (Anila Mitra, 50 years, IDI-08, Dacope)

The findings of this study also reveal that immediate after a disaster most of the respondents have done a thanks giving prayer from their own ways. At the community level *Miladmahfil* was very popular form of thanks giving religious ceremony of the Muslim people.

> After disaster, some changes are seen in religious activities. Some people thanks to God by doing prayer, worshiping, *milad* and so on. Some people donate money and devote committed materials which they decided during the disaster to be stop and prevent loss of their wealth. (Ataur Rahman, 47 years, FGD-04, Dacope)

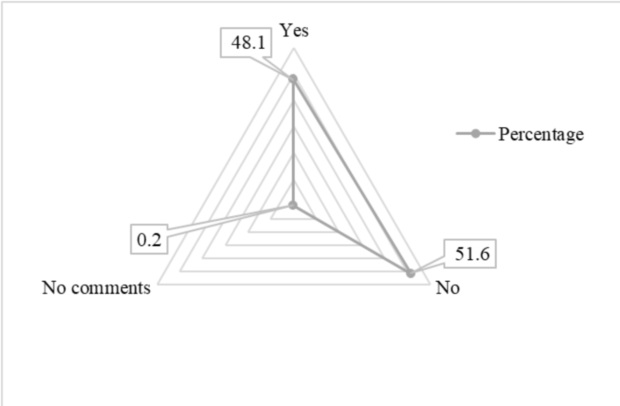

Figure 9. Percentage distribution of respondents whose religious value have changed after the super cyclone Aila in 2009. (Field survey, 2020-2021)

Similarly, another respondent mentioned that,

> We collect money and worshiping materials from the villagers after disaster and do worshiping with the help of a *purohit* (religious master). (Oshim, 37 years, FGD-05, Dacope)

This study also found that female respondents also try to express they're thanks to God in their own way. For instance, Asma Begom said,

> We arrange *talim* (gathering for religious knowledge sharing) within our village for spreading religious messages, but after the super cyclone (2009) we have failed to organize it for three years. Notwithstanding that now we are used to arrange it regularly… After Aila (2009) when we (women) have first meet for *talim,* we have prayed to Allah and given thanks to him to protect us. (Asma Begom, 45 years, FGD-08, Koyra)

Role of religious symbol in disaster management, according to the findings of this study, generally happened in three phases of a hazard. But these roles generally happen unconscious behavior. Controlling stress and increase of courage was another important role of religious symbols and practices shown by the findings of this study.

Religion's role on climate induced migration

The findings of this study also show that in the post-hazard phase international migration also happened based on the religion. On this point a respondent mentioned,

> from my neighborhood, after the super cyclone Aila I have seen some Santayana religious people have migrated to India. It seems to them as India is a country of Santayana religion and here, they were depriving of basic needs. Some people have relatives in India and after the super cyclone Aila they have gone to their relatives. (Firoz Ahmed, 39 years, FGD-06, Koyra)

Similarly, another respondent said,

> After the Super cyclone Aila, some of my family members have gone to India for five years to seek livelihood. (Nomita Roy, 52 years, IDI-5, Dacope)

Role of religion on the upper-class people to disaster management

Although few people (19.3%) in the social survey received the upper-class people's aid in the super cyclone Aila (Figure 10). But in the first phase findings of this study depict that rich people used to play an active role in local disaster coping mechanism. For instance, during a natural calamity most of the rich people come forward to assist poor people from their moral concern. But from the religious point of view these activities is a mandatory task of the upper-class people.

> During Aila (2009) in our area Mr. A (one of the richest persons of this study area) have opened his door and made his home as a primary cyclone shelter. Besides, he also given us food and cloths as much

> as he can…I think he have done this not for humanity but for fear of God. As he is a pious man as per my knowledge. (Heron Kumar Mondal, 52 years, IDI-01, Koyra)

Similarly, another respondent mentioned that,

> In our religion, Allah ordered the rich people to donate to the poor and vulnerable people not as aid but as a right. I am confident that in a disaster management such philosophy can contribute significantly…Even after Aila (2009) I have seen a huge amount of aid and relief have come here in the form of Zakat. (Abul-Basar, 63 years, KII-2, Koyra)

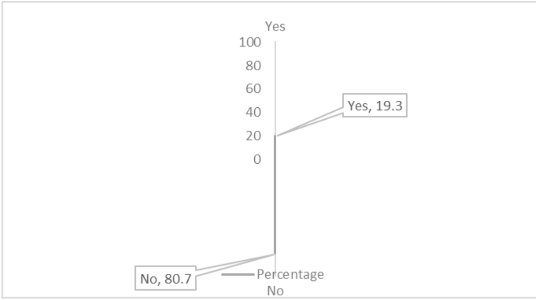

Figure 10. Percentage of respondents who have received the upper-class peoples aid during the supper cyclone Aila in 2009. (Field survey, 2020-2021)

Discussion

Over the past few years, building a resilient community for any crisis management has gotten its popularity both in the national and international spheres. Therefore, several international frameworks and legal instruments like SFDRR are used to emphasize understanding cultural aspects apart from political, economic, and geographic aspects (Roy et al., 2023). In a line with this view, applying the mixed approach of data collection this study has tried to describe how different religious institutions, religious masters, and religious codes and customs govern people in three phases of disaster management.

However, through a systematic review and meta-analysis, Sheikhi et al. (2021) have found a significant role of religious institutions in terms of early responses and taking part in the recovery phase. Similarly, Paulson and Menjívar (2012) also explored the popularity of religious institution-based relief distribution in India. Supporting these earlier studies, this empirical also reveals that religious institutions in southwestern disaster-prone coastal areas not only take part in early responses and recovery phases but also religious institutions play the role of the support center. Especially, collection and distribution of relief in the post-disaster phase were also found in the study of Mohit et al. (2013) and Ha (2015). Nevertheless, unlike other studies, most of the respondents (93%) did not agree on the role of a religious institution in preparedness and mitigation efforts due to a lack of sufficient resources in the religious institutions.

According to Ibrahim et al. (2019), the cause of non-response to early warning of the southwest coastal areas the local people was due to having mistrust on modern disaster management system and having deep faith in religion. In that case, the findings of this study can guide the policymakers for future planning. For instance, religious institutions often act as a shelter was another important finding of this study which was hardly presented in earlier studies. But to gather people in one place in any crisis period was not so easy especially in those areas where the follower of different type of religion lives together like Bangladesh. Notwithstanding that this study has found most of the respondents (98%) have agreed that during a disaster there was no religious barrier to take shelter in religious institutions. From this viewpoint, through this study, it can be recommended that religious institutions can be used as a shelter and it would be easy to encourage people to take shelter in religious institutions.

The findings of this study also revealed that in terms of receiving financial aid most of the respondents supported the religion-based association rather than institutions. The result of such query indicates a lack of coordination between religious institutions and religion-based associations since about 98% of respondents did not believe religious institutions can play a significant role in social instigation. According to Ha (2015) using religious believes and systematic coordination between local government and various religious institutions can be developed a resilient disaster management program in those societies where the multi-religious people live together. Similarly, most of the respondents of the KII through this study have recommended doing integration between various religious institutions and government organizations.

Howsoever, the findings of this study further present multiple responses about religious master's role in disaster management. Though the majority (87%) of the respondents did not believe that religious masters have a direct role in disaster management, most of the respondents of KII and IDI believed that raising awareness was a very common role that used to practice by religious masters in the coastal areas. Besides, some latent roles like encouraging upper-class people to donate to vulnerable people and assisting local disaster management committees via giving advice were other important findings. Some earlier studies (i.e., Ensor, 2003; Hope & Jones, 2014; Yari et al., 2019; O'Connell, 2018) have emphasized that religious masters generally lead people to grow fatalistic beliefs which discourage people to do disaster preparedness behavior. But, in this study, no such evidence has found that religious leaders have created any fatalistic beliefs among the respondents. Conceding Call (2012) and Hussain et al. (2014) findings, that in some disaster-prone areas religious masters are generally considered as divine individuals by the local people, this study also evident that religious masters have a very low impact on the southwest coastal areas except some oral motivation.

Coming to religious influence on local people's pattern of beliefs, the findings of this study found most of the respondents believed disasters happen because of their misdeeds. Like O'Connell's (2018) study, this current study also evident that the religious masters in southwest coastal areas of Bangladesh have a significant influence on people's understanding regarding the cause of the disaster. However, this study also found that immediately after a disaster people become more religious than in the pre-disaster phase. After a disaster to increase faith in disaster and to express the faith in religion some respondents of this study have organized some religious concerts. Such findings indicate that religion plays a vital role in increasing collective consciousness.

However, to understand the role of holy books in disaster management this study has explored that most of the respondents (82.2%) believed that these religious objects play a vital role to make them calm in any crisis moment. Likewise, Aten et al. (2019) and Sheikhi et al. (2021) also mentioned that the religious code and practices have a psychological role in a crisis moment. Similarly, this study also explored that religious values have grown moral concerns regarding disaster management which can be characterized as the social supportive role of religion in disaster management. Unlike many other studies, this study found a notable role of religious symbols in disaster management. For instance, about half of the respondents have believed that during a disaster reciting sacred words has helped them to increase their mental strength. Through building resilience these findings do not have a manifest impact but for crisis management, this finding can give a direction to provide victim support in a natural event.

Moreover, this study partially found the role of religion in climate-induced migration. Since very few respondents have discussed this issue so this study failed to draw a strong conclusion on this point which can be one of a limitation of this study. Therefore, it would be recommended to do further study on this statement. To understand the power of religion in disaster management it also found that religious code and practice make rich people donate their surplus wealth to vulnerable people which have an important contribution to local coping mechanisms that did not highlight in the study of Garai (2017). Overall, this study has revealed that religion makes people do different types of activities associated with disaster management in the southwest disaster-prone areas of Bangladesh. Most of them happen unconsciously but can play a significant role to increase capacity to do a community-based disaster risk reduction intervention.

Conclusion

In conclusion, it has been clear that religion as a cultural element has a significant influence on the local coastal people of Bangladesh which can strengthen the local disaster management strategies. Certainly, social support and collective responses are so important to manage any crisis. On this point, this study has highlighted the social supportive role of religious institutions in a natural event. Similarly, the leadership role is another important role that needs to guide people to meet any challenges. In a line with this perception, this study also found that religious masters and leaders have a significant role to motivate people to deal with the immediate shock of a disaster. Remaining psychologically strong is also very important to manage any natural hazards. In a direction with existing literature, this study also found the most important role of religious code, value, and practices to enhance coastal people's psychological strengths in any natural events.

Besides, increasing collective consciousness, uniting people under one umbrella, and increasing the sense of moral responsibility is also important findings that can help people to reduce their vulnerabilities. In terms of community-based disaster risk reduction interventions, these findings can guide policymakers to understand the importance of integration between religious elements and different development organizations. Such a collaborative approach can build resilience among the local communities. However, this study also highlighted that based on religious master's knowledge and experience they used to serve their societies but still they have a notable influence on society. So, it would be recommended that if some knowledge enhancement programs can be launched in the coastal areas regarding disaster management with key emphasis to religious masters, then these groups of people can contribute more to the local disaster coping mechanisms.

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Availability of data and material
Upon request

Code availability (software application or custom code)
Upon request

Conflicts of Interest
The authors declare no conflict of interest.

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