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Congratulatory Message

In these congratulatory remarks, I would like to speak on the emerging world's civilization based on the philosophy of Godism. Originally, modern western civilization was highly dynamic, had creative vitality, and played a magnificent role on the historical stage. During its progress through antiquity, the Middle Ages, and modernity, western civilization maintained vitality with its own unity and creative energy.

However, when it clashed with other civilizations in modern times, its limitations became exposed. Through the two world wars, mankind, which had formerly believed in human reason, despaired at human brutality and cast a doubt on human reason as the basis of modern civilization.

The human nature created by modern materialistic civilization and competitive society is truly terrifying. What is ruling modern mass society is power and the jungle ethics of the survival of the fittest. This is an outcome of dialectic philosophy which understands the self and the others in a relationship of conflict.

The crisis of modern civilization doesn't stop here. In this age, the view of values is overturning, and the meaning of life is distorted, primarily because the relationship between God and human beings has been dismantled. Many people have foretold a shift of the center of civilization from the West to the East.

Western civilization, after the age of the Atlantic, will be succeeded by the Pacific civilization. The creativity and energy to lead world civilization are even less hidden in the Pacific civilization which is now about to emerge. At this point, I would like to suggest a few characteristics of the philosophy that will lead world civilization.

First, the philosophy to lead world civilization must have a firm moral value and moral root. The value of society and culture cannot be measured merely in terms of technological advancement or material superiority. Rather, the maturity of the society and culture should be esteemed by the standard of morality.

Second, the philosophy to lead world civilization must be able to embrace both the civilizations of the East and West and make a new creation out of their integration. It should bring harmony to the materialistic civilization of the West and the spiritual civilization of the East.

Third, the philosophy to lead world civilization must discover God, who was lost in modern civilization, and adopt absolute values centered on God as its foundation. Out of an excessive emphasis on human reason, western civilization has dethroned God, replacing Him with humanistic philosophy, and even promulgating atheism and materialism. A person who has lost sight of God can only see spiritual darkness, existential emptiness, and the meaninglessness of life. Only when God is served at the center can the true and ultimate meaning of human beings and the universe be restored, and the meaning of life and the foundation for absolute values be found.

I see that the philosophy best equipped to lead the world civilization of the future is the philosophy of Godism, that is, Unification Thought. The philosophy of Godism is a new system of philosophy to bring proper order to the relationship between God, human beings, and nature. The philosophy of Godism, while overcoming the limitations of western philosophies, reestablishes the importance of the meaning of eastern philosophies.

I sincerely hope that this symposium does not end in the exchange of opening remarks or opinions of various scholars, but that by applying the philosophy of Godism, a turning point for forming and reconstituting a new value system will be achieved. Now, we must overcome the obstacles to the formation of the world community, such as national selfishness, division, national supremacy, and nationalistic groups, by uniting in the spirit of cooperation and living for the sake of others. In this way, I sincerely hope that in the new millennium, God's will will be realized on earth.

Dr. Jin Sung-Bae,

Chair of Hyojeong Academic Foundation

Congratulatory Message

Good morning, everyone. Respected guests, distinguished scholars, ladies and gentlemen. It is my great honor to extend my heartfelt congratulations on the opening of the Sixth Hyojong International Academy Conference in 2025.

I would like to express my deepest gratitude to Dr. Pyon Yong-sik for his tireless dedication in organizing this important event. I also wish to share my congratulations with all participants who have gathered here today. I would like to particularly thank the scholars presenting their research at this conference.

Your insights and findings hold the potential to illuminate solutions to the complex challenges facing our global community. And I look forward to the meaningful contributions your work will inspire. Humanity, having entered the era of the Fourth Industrial Revolution in the 21st century, now faces unprecedented uncertainty regarding the future.

The rapid advancement of artificial intelligence has brought remarkable convenience to our lives. Yet, it also raises profound questions about human dignity and identity. Many conflicts between nations continue to escalate, often culminating in war, while the gradual decline of human values has contributed to a rise in violence.

As a result, the vision of a peaceful world seems increasingly distant. In this context, the role and significance of the Sixth Hyojong International Academy Conference are more vital than ever before. Distinguished guests, through this conference, I hope you will explore new value strategies and approaches that can contribute to sustainable prosperity and lasting peace for all humanity.

I wish this conference every success, and I pray that Heaven blesses our gathering and all participants throughout this meaningful endeavor. Thank you very much.

Dr. Moon Seong-Jae,
President of Sun Moon University

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AI and Theological Anthropology

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Abstract: This This paper explores the relationship between human beings and AI, building on the concept of human beings as the imago dei, that is, the "image and likeness of God", and a concept of AI as imago hominis, created in the image and likeness of human beings. The two, human beings and AI are increasingly symbiotically interrelated. Moreover, human development, and human evolution are increasingly dependent, or interdependent, on AI development and evolution. This situation of interdependence and co-existence will only increase over time, giving rise to both great risks and great opportunities, a circumstance that has been part of human existence for millennia. The risks related to humanity's relationship with technology have always been evident throughout human history, from the invention of fire to the invention of nuclear power. AI takes this relationship to a new and unprecedented level of complexity. As human beings strive to establish a world of peace and sustainable abundance, utilization of AI is imperative. At the same time, the alignment of AI with human values is imperative, as the same time that human engagement with and partnership with AI is existentially necessary. Insofar as human purpose and destiny is related to a divine purpose and providence, technology in general, and AI in particular are necessary components that contribute to the fulfillment of that providence. With this in mind, it important to revisit the understanding of the relationship between mind and matter, spirit and matter, and intelligence and matter, moving toward a more integrative, non-dualistic approach. In this way, theological anthropology and the theology of technology may complement one another.

Keywords: AI, co-existence, interdependence, human values, theological anthropology, theology of technology

1. Introduction

This presentation seeks to look at AI through a theological lens, beginning with theological anthropology as a way of understanding the nature, purpose and general condition of the human being, more or less through a framework of creation, fall and restoration or eschatology.

In the second part, I engage in theological reflection on AI, and technology in general, highlighting correlations between theological anthropology and the ways in which we think about AI, noting that there is a useful creation-fall-eschatology framework that, as with theological anthropology, applies fruitfully to our growing understanding AI.

Finally, I will consider AI from a more eschatological perspective, asking the question "What are we going? What is our destiny with AI? Does AI, or technology in general, have a place in divine providence?

1.1. AI and Religion

AI is having dramatic impact on many fields, including medicine, education, finance, and national security. Like many technological developments---fire, writing, tools, steam engines, railroads, automobiles, air travel, gun powder, the computer, nuclear energy, digital communications---AI is transformational. The impact of AI is massive, even in these early stages of its development, especially with the emergence of generative AI, LLMs, and robotics. Some envision a moment, not far in the future, when AI may surpass human beings as the most intelligent species, and giving rise to concepts such as an AI singularity, when AI exceeds human intelligence; transhumanism, wherein human capacities are augmented dramatically by AI capacities; posthumanism, which envisions a time when human identity and anthropocentrism are called into question and the emergence of a post-human reality emerges.

AI is also impacting the sphere of religion. Religious institutions such as the Roman Catholic Church and the World Council of Churches are voicing concerns. Previously Pope Francis, and more recently Pope Leo IV have expressed concerns about the impact of AI and the need for controls. Other religions have followed suit.

And yet all religions are already interacting with AI, from GPS to ChatGPT, ClaudeAI, and Bard. In some cases, religions utilize robotics as part of liturgical practices, delivery of daily scripture readings, chants, and calls to prayer, not to mention the use of AI for assistance in sermon preparation, scripture interpretation, etc.

A wide range of publications by theologians and scholars of religion have emerged over that past couple of decades, in response to AI. Elia Delio, an expert on the thought of Teilhard de Chardin who holds an endowed Chair in Theology at Villanova University, has published widely in the field, including **Re-Enchanting the Earth: Why AI Needs Religion** (Orbis, 2020), Noreen Herzfeld of St. John's University has published **In Our Image: Ancient Questions Posed Anew by AI** (Fortress, 2002); Beth Singler and Fraser Watts have edited a volume entitled **Cambridge Companion to Religion and Artificial Intelligence** (Cambridge, 2024); Justin Lane has published **Understanding Religion Through Artificial Intelligence: Bonding and Belief** (Bloomsbury, 2021); Ian Barbour has written *"Neuroscience, Artificial Intelligence, and Human Nature: Theological and Philosophical Reflections"* (Zygon: Journal of Religion and Science, 34/3, 1999); John Pudderfoot, **God and the Mind Machine: Computers, AI and the Human Soul** (1996).

1.2. Theological Anthropology

Genesis 1:26-28 describes the creation of Adam and Eve as being in the "image and likeness of God," with a mandate to fulfill a God-given purpose to "be fruitful and multiply…and have dominion over….every living thing." This text forms the basis of *imago dei* theology which underlies an understanding of the intentional uniqueness of the human being among all of God's creations. Human beings, moreover, who are created male and female, reproduce the *imago dei*. This theology grounds the understanding of the uniqueness of each human being descended from this first couple, endowed by God with the dignity associated with being made in the image and likeness of God; this unique trait of human beings undergirds the concept of human rights.

Unique traits of human beings include: freedom of the will, responsibility to do one's duty or to do what is right, reason or rationality, consciousness, conscience as in capacity to distinguish right from wrong.

Of course, the book of Genesis goes on to speak of the **Fall of Adam and Eve**, a sin that led to their being expelled from the Garden of Eden and cursed, setting up the condition that all their descendants, while sharing in the image and likeness of God, are stained with the taint of the first couple's sin, later known as original sin.

Christian providential history then proceeds as an effort to repair or atone the original sin and its legacy throughout history, a legacy that evidenced the damage done to the human conscience, heart and mind, resulting in a wide array of sins, one poignantly expressed in the first murder committed by Cain, the first son of Adam and Eve.

Providential history may be interpreted to consist of the effort to mitigate the effects of the fall, and ultimately atone for the original sin, through the sacrifice of Jesus, and to restore humanity back to the original state.

In effect, this history describes a basic narrative of creation, fall, atonement and redemption or restoration.

There are comparisons with the development of AI, and perhaps the story of all major technological developments utilized by human beings.

2. Discussion

2.1. AI in Theological Perspective

The creation of AI is very different and yet somewhat similar or analogous to the "imago dei" theology discussed above. AI has been described as "imago hominis", a form of technology that might be described as in "the image" of the human being, its brain and its intellect, albeit "artificial", that is, non-organic or non-biological, and, perhaps, from a theological perspective, lacking in attributes such as a soul or spirit.

The creation of technology or tools has been part of human history, and linked closely to human survival and human development. One might even say that the discovery or invention of technology is part of a divine plan,

a natural part of human evolution, a natural part of the fulfillment of the human purpose, a natural outgrowth of human intelligence.

Technology has always provided benefits or advantages, as well as risks and dangers, and certainly disruption as technology tends to always upset a given status quo, providing new opportunities and new risks.

There have been those who are very guarded about the advances in technology, seeing the disruptions are harmful to human beings in essential ways, undermining conscience, community and solidarity, giving way to uncharted territories that undermine a settled way of life.

On thinks of the emergence of fire, writing, steam engines, gunpowder, automobiles, highways, airplanes, nuclear power, and, now AI.

Philip Hefner, author of **Technology and Human Becoming**, has a sanguine view of technology. Philip Hefner sees the human spirit at issue in our assessment of and attitude toward technology and the many technological creations that humans spawn. Technology, he argues, tells us much about ourselves - especially our innate drive toward exploration of possibilities - and poses questions about the final meaning of creating, of human cultural evolution, and even the being of God.

Jacques Ellul, author of **Technological Society**, argues that technology is fundamentally destructive of human community and human values. Goethe's tale of the Sorcerer's Apprentice underscores concerns about technologies that can get out of control. The same is found in Mary Shelly's **Frankenstein**.

While there is great potential in technology, some see technology as being a potentially harmful, even a destructive or evil force in human history, one that leads to distortions of the human mind or soul. In the words of Max Weber from **The Protestant Ethic and the Spirit of Capitalism**, the modern rationality that produced science and the industrial revolution created an "iron cage" and a disenchantment [entzauberung] of the world

If we define AI as an *imago hominis*, a tool that is made in certain respects in the image of the human being, particularly the human brain, we may also see that AI is capable of departing from its prescribed path, entering into a realm of **the Fall**. This is known as the **alignment problem**, giving rise to an emerging field of AI Ethics, an effort to provide guardrails for AI and to provide the education, coding, or algorithms that will humanize AI.

Indeed, it is commonplace to have both an appreciation for the potential benefits of AI while also fearing its unintended consequences.

The effort to mitigate the risks is widespread, while at the same time, there is an irresistible interest, curiosity, and perhaps natural exploratory drive to see where the trail leads. AI Ethics, or alignment, is the effort to prevent the worst from happening. In the words of Norbert Wiener, from 1960, "if we use, to achieve our purposes, a mechanical agency with whose operation we cannot efficiently interfere once we have started it…then we had better be quite sure that the purpose that we put into the machine is the purpose we desire…" If not, we better be able to intervene. The problem, however, as Nick Bostrom says in **Superintelligence** [2014] **"**There is a long-distance race between humanity's technological ability, which is like a stallion galloping across the fields, and humanity's wisdom which is more like a foal on unsteady legs."

Some, including Yuval Harari, **Nexus** (2024) see AI as somewhat child-like, meaning that AI is human-like and in need of guidance or education. Harari is not overly confident, however, as he sees the AI "child" is increasingly becoming more intelligent, clever, opportunistic, and agent-like.

Still, efforts to instill a sense of human dignity within AI, as advised by none other than Henry Kissinger in his book, **Genesis (2024)**, are well taken, even if challenging. Others advocate efforts to code or train AI in human traits such as humility, empathy, anthropocentrism, a capacity to distinguish right from wrong, a duty to care and to avoid harm to others, etc.

Brian Christian, in **The Alignment Problem** (2020) explores the possibility of a kind of behavior modification process, developed by behaviorist scientist B.F. Skinner, to educate or train AI.

Concerns about alignment are widespread:

- European Commission: High Level Expert Group on AI "trustworthy AI"; General Data Protection Regulation (GDPR)
- Corporate World: Partnership on AI, includes DeepMind, IBM, Intel, Amazon, Apple, Sony, Facebook
- Vatican's *Antiqua et Nova*
- UN Agency on AI

- International Conference of Data Protection and Privacy Commissioners
- Peace Studies Institute of Oslo: *AI and Peace Project*
- Google: AI Principles
- Microsoft: AI for Good
- Accenture: Universal Principles of Data Ethics
- Campaign to Stop Killer Robots
- Institute of Electric and Electronic Engineers: Global Initiative on Ethics of Autonomous and Intelligent Systems, and call for "ethically aligned design"

2.2. Eschatology

One may imagine either a utopian future or a dystopian future as a result of AI, or something in between. Whatever plays out, AI is generally viewed a representing a stage of technological development that is unprecedented. No prior technological development included the development of pattern recognition, learning, problem-solving or creativity that AI represents.

This has given rise to concepts such as a singularity, or transhumanism, or posthumanism to describe a pending state of affairs that represent an entirely new reality, that is, a stage in human history when a tool or human creation reaches a point where it not only equals but surpasses human intelligence. A stage that Harari describes as agency, a capacity to learn, think and, to some extent act independently. Harari suggests that AI may best be understood as a new species, something others have referred to a post-human, a species for a post-anthropic or anthropocentric age.

I.J. Good, in **Technological Singularity Hypothesis** wrote of an intelligence explosion that results in ultra-intelligent machines that are (vastly) smarter than human beings

Vernor Vinge, in 1993, wrote of the Technological Singularity as indicating the emergence of a machine with super human intelligence, and the human era comes to an end, and there is the emergence of a new type of human, **techno sapiens.**

Nick Bostrom, writes of human betterment through technology, stating that "humans must wrest their biological destiny from evolution's blind process of random variation…favoring the use of science and technology to overcome biological limitation" in *History of Transhuman Thought, 2014, Open Journal of Philosophy*

The dystopian scenarios are as troubling as the scenarios of abundance are inspiring. Consider points made by Kissinger in **Genesis** indicating that the age of AI brings:

- Killer Robots
- Killer Nanorobots
- Linkage of AGI and Biological Weapons
- Autonomous Drones
- Eugenics
- False Positives and False Negatives in Criminal Justice Recommendations
- AGI in Hands of Terrorists
- Disastrous unintended consequences
- Doomsday, Apocalypse

On the more utopian side, however, Kissinger notes that through AI the opportunities abound:

- Abundance Grows
- Capacities to Provide Guaranteed Incomes
- Criminal Justice Recommendations [predictive behavior]
- Government Efficiency
- Manufacture and Agriculture Advances
- Financial Management [algorithmic trading and algorithmic disctribution and algorithmic DOGEs]
- Economic Development, Decline in Poverty, Greater Equalization of Wealth

- Drudgery Jobs Eliminated [Guaranteed Incomes]
- Geospatial data from AI helps solve climate change, and bolster human security
- Space Travel Grows Exponentially
- Diplomacy and Peacebuilding Enhanced

Others have interpreted AI's rise in theological, even providential terms, representing a new stage in human development, a stage that may be interpreted not only materialistically, but spiritually. Again, Elia Delio draws on the theology of the Jesuit paleontologist Teilhard de Chardin to offer a vision of symbiosis between the spiritual and the biological, and between the biological and the material, as AI, like all technology, is something of an extension or augmentation or expansion of our human capacities.

According to this vision, technological development is not some alien force that is at odds with human development or God's design or providence for human beings and the cosmos. Moreover, expanding on this line of thought, Delio sees no contradiction or separation between the evolution of human consciousness, human capacities, and technology. As human beings evolve or develop, there is a corresponding technological development.

Consider the invention of the printing press and its association with a rise in literacy, democracy, and a religious reformation that emerged in Germany, Switzerland, and England. The emergence of AI, Delio suggests, will lead to religious development, even a new axial age, referring to the Axial Age described by Karl Jaspers when Buddhism, Confucianism, Platonism and Aristotelianism, as well as developments in Judaism and Hinduism, emerged dramatically and simultaneously in various parts of the world.

AI, in this sense, despite the threats it represents, may represent an enormous evolutionary advance for humanity, in science, medicine, governance, education, poverty eradication, and mitigation of climate change. An age of abundance.

2.3. Theologically, perhaps a Kingdom of God.

Consider the following:

- Will AI increase secularization and de-religionization, or will a religious explosion accompany AI's development, a la Protestantism's leveraging printing presses
- Is there a **religious counterpart** to AI's development?
- Internet and AI coincide with shifts from organized religion to spirituality; nones and SBNRs? Not exactly secularization, and not exactly retrieval of the past golden age of religion.
- Is **a new religion to be born that fits the era of AI**? Does it look like transhumanism?
- Is there an **anthropic providence** guiding human development and scientific development? An intelligent design? Is there a Teilhardian Telos?
- Is God guiding the human project to a **new Axial Age**?
- Is there a link between the awakening and the recognition of the "intelligence" of the machine and a recognition of the **feminine aspect of God**?
- Is AI **a lifeboat for humanity** to help us solve aspects of human suffering and disease, poverty, climate change, inequality, and poor education, and conflict and war?

The threats are real, as Henry Kissinger, and others have warned. These must be addressed and overcome.

For FFWPU AI may be understood as a providential accompaniment of an envisioned new era, or age of cheonilguk. Perhaps this will be achieved through responsible, sustainable co-creation, a fulfillment of the "three blessings" from the first chapter of the Book of Genesis.

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Headwing Ideology, Natural Subjugation

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Abstract: Jesus taught that reconciliation with our enemies comes not through religious practices or appeal to courts of law, but through two steps. First, complete self-sacrifice for our enemy's sake. Second, presenting a path forward together. Complete self-sacrifice leads to one's enemies' voluntary surrender. Examples are found in the courses of Jacob and Jesus. Jacob did not provide a path forward together. Even though Esau desired to stay together, they separated. Through the Holy Spirit, Jesus provided a path forward, and Christianity was born. Today, united with Dr. Hak-Ja Han, in relation to UCI and the governments of Japan and Korea, our movement can sacrifice everything and offer the "headwing" ideology as the path forward together. I propose that the essence of this ideology is sexual abstinence until marriage and lifelong fidelity in marriage. It is headwing because people of conscience on both the Left and Right, of all religions, races and nations, support it. Therefore, it is the common base for give and take among nations and religions, which is the key to world peace.

Keywords: sacrifice, offering, surrender, ideology, government, courts, Cheon Il Guk, chosen people

1. Introduction

This Dr. Hak-Ja Han declared the opening of the Cheonil Sanctum, with humility and honesty, that we have not established Heavenly Parent's sovereignty: "As I conducted the Entrance Ceremony, I felt as though I would burst into tears. True Parents' responsibility is to create the environment on earth in which people can attend Heavenly Parent. …However, …an environment in which everyone could attend Heavenly Parent substantially has not been established [1]."

On the national level, we have set the foundation of faith, but not the foundation of substance. Sovereignty results from recognition of the Abel nation by the Cain nation(s), which is the foundation of substance. Cheon Il Guk sovereignty, centered on the Cheonil Sanctum, can begin with the Republic of Korea recognizing HJ Cheonwon as a self-governing peace zone, specifically, a charter city. "A charter city is a new city granted special jurisdiction to create a new governance system and enact policy reforms [2]." This is the foundation for Cheon Il Guk sovereignty to be established throughout the Korean Peninsula as one nation, which is the foundation for Cheon Il Guk sovereignty to be established in all nations as one world.

In this paper I share lessons from Jesus and Old Testament figures that show us the path to set the foundation of substance. I begin with the Sermon on the Mount. Jesus said that oneness with Cain should precede our making an offering to God. "Therefore, if you are offering your gift at the altar and there remember that your brother or sister has something against you, leave your gift there in front of the altar. First go and be reconciled to them; then come and offer your gift." (Mt. 5:23) According to this teaching, we must reconcile with the parties that have something against us before pursuing our religious practice. Exposition of the Divine Principle [3] makes this point when it states that, after Jesus death on the cross, the Jewish leadership expected to go to heaven through their religious practices but ended up in hell. And it counsels us: "Recognizing that similar events may occur in the Last Days, each of us should seriously examine ourselves [4]."

After presenting this principle in the religious context, Jesus made a similar pronouncement in relation to courts of law. "Settle matters quickly with your adversary who is taking you to court. Do it while you are still together on the way." (Mt. 5:24-26) Jesus' teaching aligns with Rev. Sun Myung Moon's statement that judges, lawyers and prosecutors have no place in Cheon Il Guk. It also aligns with Dr. Hak-Ja Han's words, given as Foundation Day approached: "Those who are involved in these unnecessary lawsuits in Korea and overseas should repent. I wish to tell them to put everything down and start afresh through Foundation Day [3]."

Jesus taught us how to bring Cain's natural subjugation. "I tell you, do not resist an evil person. If anyone slaps you on the right cheek, turn to them the other cheek also. And if anyone wants to sue you and take your shirt, hand over your coat as well. If anyone forces you to go one mile, go with them two miles." (Mt. 5, passim) This is the essence of God's unconditional love. To give everything to our adversaries unconditionally is our path to become "perfect as your Father in Heaven is perfect." (Mt. 5:48)

2. Discussion

Seeking salvation and justice through religious and judicial systems is to ignore Jesus ideology, which is to give more than your adversary expects, in fact, to give everything you have. Through true love, we turn our sacrifice into our offering. "Sacrifice" and "offering" refer to two different hearts with which we do the same thing. Isaac turned Abraham's sacrifice of him on Mt. Moriah into an offering. Joseph turned his brothers' sale of him to merchants into an offering: "you meant evil against me; but God meant it for good." (Gen. 50:20) Joseph and Rev. Moon turned imprisonment into an offering. Dr. Hak-Ja Han turned her sacrificial course into an offering. Exposition's words [3] on a Man attacking Jacob at the ford of Jabbok apply to all these events. "God's purpose in doing this was not to make Jacob miserable, but to help him secure the position of Abel and complete the restoration of his family by winning the qualification to rule the angel [3]."

To protect the world from Satan's attack, Rev. Moon offered his life representing the world. "God cannot sympathize. Instead, He had to whip His departing son. I understand God's situation. …God has been merciless to me. God opposed me every step of the way as I climbed up from the very bottom. Yet I endured it all because I knew that God would be all alone without me. I passed all the tests and now God believes in me [5]."

2.1. The Way of Jacob and Jesus

Jacob's dream was not to create a wealthy family, clan, servants and flocks; it was to reconcile with his elder brother. For that purpose, he offered his family, clan, servants and flocks to Esau. He won the victory of sexual purity at the ford of Jabbok and then bowed humbly before his elder brother. True Father applied the "theology of rejection" in his analysis of Isaac and Rebekah's family at the moment of Jacob's return from Haran:

> "Did Jacob come back triumphantly and announce, 'I am the victor representing the three generations, so now since you have sold off your blessings, you must come and be subjugated under me'? [If] Jacob have said that …what would Esau have done? Wouldn't he have kicked him out? At that time, there were …Jacob, his mother and father. These three were …wondering what Esau's response would be.
>
> "If Esau rebelled against them, the whole purpose would have been broken down. But …Jacob's attitude was humble. He was dedicated, living for the sake of others. He was not centered on himself, but centered on others. That is the key that brings Satan to be subjugated under Abel."
>
> "Now we know the meaning of natural subjugation. Jacob worked so hard, but he was humble. When Jacob behaved as he did, bowing down before Esau, do you think his mother was very happy, or was she angry, saying, 'You are Abel, the blessed one, and you should become more dignified'? No, she applauded what Jacob did. Her husband, Jacob's father, applauded him also, saying, 'You have done right.' That was natural subjugation. Of course, Esau, too, felt very good. …Esau, in Cain's position, embraced the younger brother in Abel's position. This was an historical embrace."

Isaac's and Rebekah's heart harmonized with that of their son Jacob, as he approached Esau.

> "Then, when Jacob finally met his older brother Esau, he did not say, 'Hi my brother, how have you been?' He praised Esau calling him, 'My lord, my older brother.' As he approached Esau, Jacob bowed down to the ground seven times while saying to Esau, 'For to see your face is like seeing the face of God.' He did this deliberately. Notice, he did not run up to him. Had he ran to his brother, do you know what could have happened to him, facing the soldiers who were prepared to kill him?

In order to avoid any harm, he moved forward while bowing and shedding tears.

"This environment that was created by his efforts moved his brother, and then Esau embraced Jacob. Jacob cried out while pressing his face to Esau's, saying, 'My lord, here the sinner is finally visiting you. Even if I say my gratitude thousands of times, it is not enough. So, please kill me right here for my sin against you."

Jacob took Esau's sin upon himself, took the blame for the animosity that Esau had harbored for 21 years. He did so in total sincerity. This is the victory of Jacob, the model for all religions and nations.

"Hearing such a plea, Esau accepted his gifts. Although Esau never had a loving heart, he could not take any action against Jacob. So, he accepted the gifts [6]."

Jesus' aspiration was to bring the Kingdom of Heaven on earth at the cost of his life. When the chosen people's leaders rejected him, he told the disciple who rose up to protect him in Gethsemane to put down his knife. "Jesus said to him, 'Put your sword in its place, for all who take the sword will perish by the sword. Or do you think that I cannot now pray to My Father, and He will provide Me with more than twelve legions of angels?" (Mt. 26:52-54) Jesus had proclaimed his message, and now it was up to the government to decide his fate. He bowed to the High Priests and Procurator. When the religion sent him to die, and the government acceded to their wishes, he claimed it as God's victory. "All this was done that the Scriptures of the prophets might be fulfilled." (Mt. 26:56)

As with Jacob and Jesus, our Unificationist dream is not to create a wealthy religious movement. It is not to defend ourselves with righteous anger. It is to give our lives to win the hearts of our brothers and sisters, nations and religions that have something against us. Can our movement attain the level of unity and faith that Jacob's family had? The heart of Jesus saying "forgive them, they know not what they do"? With faith in the teaching of natural subjugation, can we offer everything to our adversaries, to our Christian brothers and sisters? To the governments of Japan and South Korea? Will this bring natural subjugation?

"You will love [your home church area] as a parent but govern them as a king. …*Home* church is the altar where you and your family go to pray and present yourself as a living sacrifice [7]."

2.2. The value of ideology

Together with that total living offering, we need to present a vision for the future—an ideology. The communists started with an ideology. They did not succeed by telling people to worship Lenin, but by offering a compelling ideology and vision. When they took over the Russian government, they had social policies that they could quickly implement. "The Bolsheviks won popularity with their program promising peace, land, and bread: an end to the war, land for the peasantry, and ending famine. …the Bolsheviks and other factions gained popular support to advance the revolution [8]." This was the external third world war. We won this war through the Cain-Abel reversal in Moscow and Pyongyang, centering on Rev. Moon.

The LGBTQ movement also presents an ideology: free sex is true love. Through the arts and media it glorifies this ideology and villainizes those who disagree. It then formulates changes in laws in the arena of education, marriage, media and moral standards. This is the internal third world war, the Adam-Eve-archangel dimension that we must win, centering on True Mother. Now is the time to proclaim Heaven's headwing ideology.

Lacking a clan-level ideology, Jacob declined Esau's invitation to join him, and traveled to a location distant from Esau's. He could not proceed beyond his family, which was only part of Abraham and Sarah's lineage. Jesus gave us a global spiritual ideology based on the Old Testament and his own genius. Due to his crucifixion, Christianity had no foundation for physical world governance.

We need to set forth a simple ideology. We know well that "the perfected home is a unit or model for the heavenly society, nation and world [9-12]." "The Kingdom of Heaven is the spherically extended form of a family [13]." "Cheon Il Guk is the expansion of the family law [13]." This is the headwing ideology. Its essence in practice is, sexual abstinence until marriage and lifelong fidelity in marriage. This is the essence of God's blessings and

commandment to Adam and Eve, confirmed and amplified by Jesus in Matthew 19. It is the foundation for a family ideology, a system of ideas and ideals that forms the basis of economic and political policy. It is "headwing" because people of conscience on both the Left and Right, of all religions, races and nations support it. It is the common base for give and take among nations and religions on the basis of both science and scripture.

Social science proves that the practice of this ideology leads to personal and societal health, happiness, peace and prosperity. When nations accept this, they will enact policies in the areas of education, media, health, taxation and welfare that reward three-generation family life. I note the recent 100-0 vote in the US Senate and 409-2 vote in the House of Representatives against deepfake pornography, the "Take It Down Act," led by Melania Trump. The Supreme Court recently voted in support of age-verification laws protecting teens from pornographic web-sites, and Kathy Hochul, the Democrat governor of New York, has announced a statewide policy restricting cell phone use in public schools. The acceptance of headwing ideology will naturally lead the world to True Parents.

2.3. The Victory of the Chosen People

Dr. Hak-Ja Han has called the blessed couples the chosen people. In Rev. Moon's words, "Those who go the path of faith must be careful not to be proud and arrogant [13]." And Dr. Hak-Ja Han put it this way:" God has selected many chosen people, …not for the sake of that particular person, family, clan or race, but for the sake of God's nation [14]." We must bow down and repent. Bow down to whom? First, to Dr. Hak-Ja Han, with Rev. Moon in the spirit world. Second, to our enemy. The chosen people are a religion and nation that is chosen to sacrifice. The blessed couples will not receive the world's submission simply because we have built grand edifices and announced that we are the chosen people. We must see the face of God in Esau. This is Jesus' teaching to the rich young man who had fulfilled all the commandments, and asked Jesus what more he could do. Jesus answered, "If you want to be perfect, go, sell what you have and give to the poor, and you will have treasure in heaven; and come, follow Me. But when the young man heard that saying, he went away sorrowful, for he had great possessions." (Mt. 19:21-22)

Let us not be like the rich young man. Our world-level Esau is the religions that reject us and governments that want our dissolution. As did Jacob, as did Jesus, to gain the world's voluntary surrender, we must offer them everything we have, as a love offering at the cost of our lives. We are responsible to honor them as the chosen people in whose face we see God. As Dr. Hak-Ja Han said, "As blessed families, we must fulfill our responsibility. Therefore, we must teach, beginning with this nation's citizens and politicians, that they are the chosen people [15]."

3. Conclusions

Dr. Hak-Ja Han has proclaimed that we are in the substantial Cheon Il Guk. We must extricate ourselves from the hands of judges, lawyers and prosecutors, who have no place in Cheon Il Guk. We must reconcile with our brothers and sisters who have something against us before we make our offering at the altar. We must settle matters while we are on the way to the court. The application of Jacob's course to the Danbury indictment could have been to publish Rev. Moon's Foley Square speech in newspapers nationwide and call all religions to unite with us in the defense of religious freedom. We could have declared that we did not want the government to spend millions of taxpayer dollars on a court case, that we are opening our financial records to the government, and that we will follow the government's decision.

Today, united with Dr. Hak-Ja Han, in relation to UCI and the governments of Japan and Korea, our movement can sacrifice itself. As we do, we can offer a path forward together, the healthy-family ideology of sexual abstinence until marriage and lifelong fidelity in marriage. Dr. Hak-Ja Han has declared the era of the Heavenly Parent's substantial sovereignty, which is the sovereignty of the Abel blessed families together with our Cain adversaries. In 1996, Rev. Moon prophesied that this would center on Dr. Hak-Ja Han: "On the blessed family foundation, individuals and families representing Cain and Abel must unite centering absolutely on the True Parents, first becoming as one with True Mother [16]."

We blessed families have offered everything to build our movement, culminating in the Cheonil Sanctum. Now, on the foundation of Heavenly Parent's substantial sovereignty and our declaration of Cheon Il Guk nation, we

can change our adversaries' heart by offering our movement to them. "Heaven's true love is such that the more it is invested, the more it grows. …Even if our love is rejected, we should continue to love even more. …we should continue to invest until we can make our enemy voluntarily surrender [17]."

True Parents' legacy is not buildings and bank accounts. It is Heavenly Parent's way of life incarnated in blessed families who convey Heaven's blessings, based upon Heavenly Parent's original ideology, to our communities, nations and world. As one global and cosmic family, let us set aside our temple offering, set aside our case before the judge, and resolve adversarial relationships as we declare the headwing ideology. That is the foundation of substance, the foundation for a substantial nation. Then let us work to move the world in the direction of sexual abstinence before marriage and absolute fidelity in lifelong marriage. Of their own accord, nations will become family love and marriage environments in which all attend Heavenly Parent substantially.

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A Study on the Evolution of Unification Movement NGOs and Multi-level Governance

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Abstract: This paper aims to examine the evolution and current state of non-governmental organizations actively campaigning for the reunification of North and South Korea (hereinafter, "Unification NGOs") in Korean society, and to explore the directions and alternatives of governance necessary for the future unification process. The peaceful unification of the Korean Peninsula is a constitutional task mandated to all presidents and administrations of South Korea. The "National Community Unification Plan," which has been the unification plan of successive South Korean governments, aims for gradual and phased unification based on the construction of a national community through expanded reconciliation and exchange cooperation between North and South Korea. It has been modified and supplemented to suit the changing times and continues to this day. Multi-level governance is a new form of governance brought about by the decentralization of government authority due to globalization and localization. It was proposed during the European integration process to establish permanent peace on the European continent after the First and Second World Wars, and successfully integrated the current European Union, which has significant implications for the Korean Peninsula. To summarize the characteristics of multi-level governance: First, it can increase the possibility of resolving two-dimensional issues that cannot be solved in bilateral relations between hostile states by transforming them into three-dimensional issues involving multilateral participation. Second, it allows regional issues that transcend central governments and borders to be addressed through cooperation between local governments in ways that suit regional characteristics. Third, it enables efficient response and management of international issues that were previously unforeseen, due to the rapid advancement of science and technology. Fourth, it can further expand the participation of citizens and the market.

Keywords: Peaceful unification of the Korean Peninsula, Unification NGOs, Multi-level governance

1. Introduction

During the Cold War era, when the world was divided between the United States and the Soviet Union, North and South Korea did not possess the initiative in inter-Korean relations. As an extension of the Korean War, the Korean Peninsula remained within the spheres of influence of the U.S. and the Soviet Union. At that time, the unification policies of North and South Korea did not need to be termed "policies" at all; rather, inter-Korean relations continued as confrontation and conflict, conducting proxy wars between the U.S. and Soviet Union within the Cold War framework on the Korean Peninsula. Subsequently, a new era opened with the end of the Cold War and the collapse of the Soviet Union, and the North and South Korean governments gained new initiative in inter-Korean relations. The Roh Tae-woo administration gained a substantial opportunity to realize the constitutional mandate of peaceful unification of the Korean Peninsula and announced the "Korean National Community Unification Formula," which became the foundation for the "National Community Unification Formula," formulating and pursuing progressive North Korea and unification policies. Subsequently, inter-Korean relations experienced various fluctuations before holding a historic inter-Korean summit and entering an era of reconciliation and cooperation. However, the situation arose where disconnection and reconnection were repeated according to the ideology of the ruling government. The Mt. Geumgang tourism and Kaesong Industrial Complex pursued by progressive governments were closed under conservative governments, and the signing and abandonment of the "September 19 Military Agreement" followed the same pattern. In this process, South Korean citizens moved beyond South-South conflict (internal divisions within South Korea over North Korea policy), and views on North Korea and unification became diversified by generation and region, while unification movement NGOs found it difficult to adapt to radically transformed operational environments. In particular,

expectations that inter-Korean civilian exchanges and cooperation would resume under progressive governments were frustrated during the Moon Jae-in administration, creating the need to fundamentally reconsider international circumstances such as UN and U.S. sanctions, as well as unification discourse within South Korean society. The flow of Korean Peninsula affairs shows that as North Korea's nuclear and missile development enters a completion phase, the South Korean government's initiative is gradually weakening while the influence of the United States, China, and international organizations like the UN is growing. Additionally, the influence of South Korean public opinion on the stable implementation of North Korea and unification policies is also increasing, revealing the clear limitations of past government-led North Korea and unification policies.

2. Materials and Methods

Past public-private governance approaches, where the South Korean government relied on unification diplomacy dependent on the United States or utilized unification movement NGOs to influence public opinion, have become inadequate for coordinating the multi-layered interests surrounding the Korean Peninsula. This has made the construction of new governance between the government and unification movement NGOs critically necessary. South Korean NGOs were formed in earnest through the differentiation of civil society that progressed after the June 1987 democratization movement. Since the 2000s, NGOs have increased their influence on state policies and are taking the lead in various public forums. Using the May 1980 Gwangju Democratization Movement as a turning point, opposition forces formed common discourse of anti-Americanism and nationalism while criticizing the United States for protecting the authoritarian government. In the 1990s, this expanded into citizen-oriented unification movements and peace movements, leading to the formation of unification movement NGOs. Unification movement NGOs were divided into people's movements and civic movements according to the nature of participating actors. In terms of discourse determining unification movement goals and directions, they were divided into progressive, moderate, and conservative according to ideology around unification and peace, conducting activities such as North Korea assistance, inter-Korean exchange, unification education, and support for North Korean defectors. The activities of unification movement NGOs can be distinguished by period. Initially government-led, the role of the private sector gradually became important, drawing attention to the concept of "public-private governance," and governance theory was sporadically applied regarding fundamental changes in government-private cooperation. Governance refers to cooperation among hierarchical governance representing government, market governance representing corporations, and network governance representing NGOs. While political problem-solving was once absolutely the role of government, in modern society it can be more effective for corporations or NGOs to take the lead. North Korea and unification issues are also not about limiting the government's role, but about government, corporations, and NGOs cooperating from the initial stages of policy to perform their respective duties—this is the foundation of governance. Moreover, while existing governance mainly focuses on cooperation among government, market, and NGOs within a state, multi-level governance expands the scope of cooperation beyond borders to various combinations of central governments, local governments, supranational organizations, domestic and international NGOs, and domestic and international private corporations.

3. Results

Governance refers to cooperation among hierarchical governance representing government, market governance representing corporations, and network governance representing NGOs. While political problem-solving was once absolutely the role of government, in modern society it can be more effective for corporations or NGOs to take the lead. North Korea and unification issues are also not about limiting the government's role, but about government, corporations, and NGOs cooperating from the initial stages of policy to perform their respective duties—this is the foundation of governance. Moreover, while existing governance mainly focuses on cooperation among government, market, and NGOs within a state, multi-level governance expands the scope of cooperation beyond borders to various combinations of central governments, local governments, supranational organizations, domestic and international NGOs, and domestic and international private corporations. The characteristics of multi-level governance can be summarized as follows: First, it can increase the possibility of solving two-dimensional problems that cannot be resolved in bilateral relations between hostile states by transforming them into three-dimensional problems with multilateral participation. Second, it can approach regional problems that transcend central government and borders through cooperation between local governments in ways suited to

regional characteristics. Third, it can efficiently respond to and manage international problems unexpected in the past due to rapid development of science and technology. Fourth, it can further expand the participation of citizens and markets, as summarized in Table 1.

Table 1. Characteristics of Multi-level Governance [1-3]

No.	Feature	Content
1	Multi-centricity of Implementation Actors	• Formation of cooperative systems among supranational, national, and subnational levels • Operation of sustainable cooperative systems
2	Balanced Metagovernance in the Policy Implementation Process	• Complex mechanisms in the policy implementation process • Flexible crisis management response
3	Governance Regionalization	• Various mutual cooperation suited to regional characteristics • Redesigning underdeveloped border regions as new spaces
4	Expansion of Citizen and Market Participation	• NGO policy participation to mitigate social conflicts • Corporate value creation responding to social responsibility

3.1. Multi-centricity of Implementation Actors

First, multi-level governance has the characteristic of being "a system that proceeds through negotiation among the polycentricity of supranational, national, and subnational regional and local governments." Of course, the central government of a unified state with a strong executive still exercises the greatest authority, but a system enabling cooperation among various levels of political entities operates

3.2. Balanced Metagovernance in the Policy Implementation Process The text continues here.

The second characteristic of multi-level governance is that it utilizes balanced metagovernance that enables complex mechanisms to operate so that policies can be implemented smoothly and provides flexible responses when unexpected problems arise. The dictionary meaning of "meta" includes "higher" and "transcending," and metagovernance can be called "governance of governance." Multi-level governance continuously designs and manages optimal combinations that can propose and implement policies without bias toward one side through metagovernance. The complex mechanisms applied to the European Union by multi-level governance consist of three stages: policy proposal, policy decision, and policy implementation. First, in policy proposal, according to European Union treaties, the "European Commission" exclusively enjoys formal policy proposal power and legislative proposal authority. However, policy proposal requests can come from the "Council of the European Union" composed of representatives from each country's government, or the "European Council" composed of member state leaders, and can also come from the "European Parliament," the "European Economic and Social Committee," local government leadership organizations, and private enterprise organizations representing various interests.

3.3. Governance Regionalization

The third characteristic of multi-level governance is governance regionalization, which allows for various mutual cooperation suited to regional characteristics rather than focusing on capitals or major cities, and can even redesign underdeveloped border regions as new spaces. Governance regionalization can be said to mean that governance systems are constructed at the regional level rather than the macro national level. Particularly in countries where local autonomy has been implemented in earnest, citizen participation plays an important role in the policy processes and contributes to solving regional problems. The concept that emphasizes the need for local governments, regional corporations, and regional civic organizations to form networks and create partnerships based on cooperation and participation is precisely governance regionalization. As shown in Figure 1, governance structures at global, regional, national, and local levels form concentric circle structures where larger-scale governance includes smaller-scale governance according to the spatial scope where each governance is implemented.

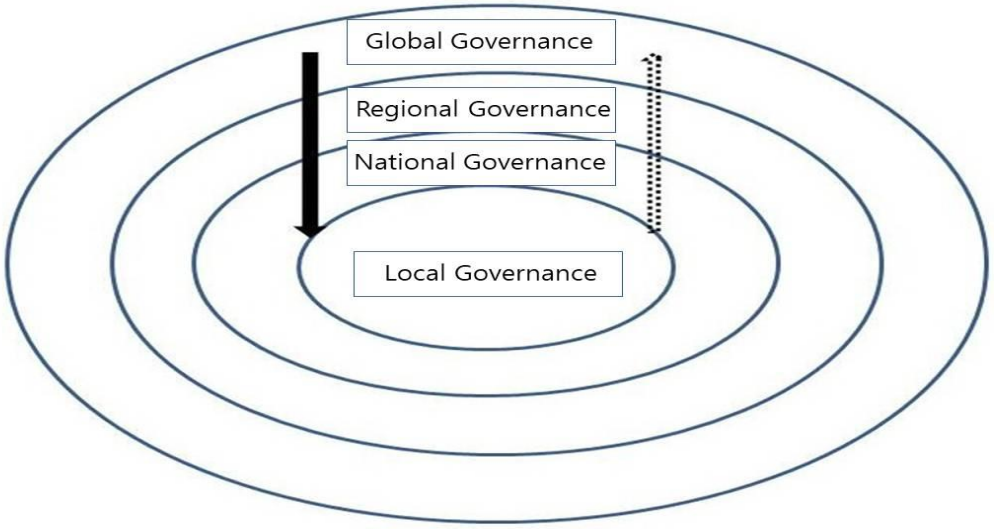

Figure 1. Multi-dimensionality of General Governance [4].

However, it is questionable whether such inclusive relationships necessarily appear in the interaction relationships among governance structure levels formed by different issue areas. Policy networks at some national level dealing with issues that have emerged as policy controversies may be ignored by other actors within regional communities, or policy networks may not be formed at the regional level for various reasons such as difficulty in generating common interest. Conversely, issues for which policy networks are difficult to form at the global level may be easily formed at the regional level where the same problem consciousness is felt. In such cases, the sequential inclusive relationship where regional governance structures necessarily become the environment for national governance structures, and global governance structures again function as the environment for regional governance structures, does not appear mechanically. Rather, the interaction relationships among governance structures at local, national, regional, and global levels from a policy network perspective appear in more complex and multifaceted forms as shown in Figure 2. According to the characteristics of issue areas and the typological characteristics of policy networks formed at each level, policy networks in some issue areas appear with overlapping actions at four levels in the form of sequential inclusive relationships leading from local to national to regional to global governance as generally considered. On the other hand, in some other issue areas, there also exist interaction relationships among governance levels where connections and mutual penetration with higher-level governance structures are not achieved, or where one of the higher or next-higher governance structures is ignored.

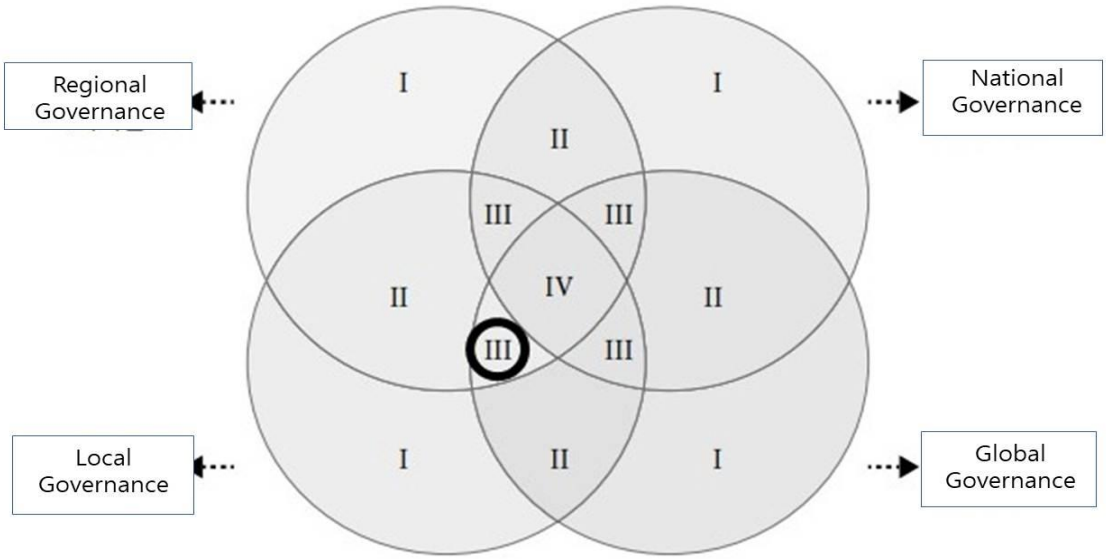

Figure 2. Multi-dimensional Governance Structure in Reality [4].

3.4. Expansion of Citizen and Market Participation

The fourth characteristic of multi-level governance is the expansion of citizen and market participation, which can mitigate social conflicts through NGO policy participation and create value responding to corporate social responsibility. Multi-level governance inevitably involves continuous conflicts such as nationalism among states and interest conflicts between supranational institutions and states, making conflict management very important. Taking the European Union as an example, in situations where economic, social, and cultural disparities exist among member states, the need to gather various interests in advance when implementing the same social policies such as labor, women, and employment has grown. However, since bureaucrats belonging to the European Commission alone cannot coordinate interests and mediate conflicts, they treat NGOs and other interest groups as social partners, drawing out participation such as opinion gathering, information provision, policy implementation delegation, and monitoring.

4. Conclusions

Recently, North Korea is making fundamental changes from its designation of South Korea to its South Korea policy, defining the relationship not as ethnic relations but as hostile state relations. The inter-Korean confrontation phase is expected to deepen, making multi-level governance urgent even for improving this situation. Inter-Korean relations can shift from tension to activation at any time according to domestic and international circumstances, and separately from this, governance must be expanded within South Korean society. For this purpose, unification movement NGOs must establish governance partnerships with the government to achieve: First, establishment of spatial and social regional governance; Second, institutional and social consensus for consistency in North Korea and unification policy; Third, North Korea assistance programs connecting corporate interests and social responsibility; Fourth, solidarity with domestic and international NGOs to address urgent issues.

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A Study on the Composition of the Concept of Unification and Its Mechanism in Unification Thought

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Abstract: This study aims to elucidate and systematize the concept of "unification" within Unification Thought, addressing its semantic ambiguity and conceptual multiplicity. As a central term in the Unification Church and its theological discourse, "unification" functions both grammatically and conceptually as a prefix and object, embodying direction, purpose, and identity. This paper seeks to propose a constructive framework by analyzing unification through the operative mechanisms of integration, inclusion/transcendence (po-wol, 包越), and holistic unity (tongjeon, 統全), ultimately offering methodological strategies such as Jeong-Boon-Hap, Hwa-jaeng, and heartistic hermeneutics.

Keywords: Unification, Concept of Unification, Mechanism

1. Introduction

The term "unification" (tongil, 統一) holds foundational status in Unification theology and ideology and is used extensively as an identifying marker (e.g. Unification Thought, Unification Church). However, its semantic scope is so broad that it can lead to conceptual ambiguity. Depending on the domain—academic, theological, social, or political—the term assumes varied operational meanings including integration, fusion, consilience, or oneness. In moving beyond abstract symbolism, the paper proposes that unification be systematically conceptualized through a structured mechanism: integration → transcendence → totality/unity. This process offers a coherent basis for theology, education, and policy-making within the Unification framework.

2. Understanding and Definition of the Concept of Unity in Unification Thought

2.1. Multiplicity and Polysemy of 'Unity'

Unity, as deployed in Unification Thought, is not mere uniformity. It incorporates dimensions of integration, transcendence, wholeness, and oneness. The goal is not reduction but embrace of diversity oriented toward purposeful harmony—the spiritual unity of ideas, values, and beings. Unification Thought, as articulated by Reverend Sun Myung Moon, connotes deep ontological unity, where spiritual and material dimensions, individuals and society, mind and body communicate seamlessly: "When this happens, it communicates everywhere… Heaven and Earth are connected."

2.2. Unity as Integration

Integration is framed as a union of equivalent elements forming a coherent whole. It emphasizes homogeneity within categorically equivalent extensions. While often misapplied, genuine integration resists syncretism or eclecticism and instead seeks systematic cooperation without hierarchical superiority.
In Unification Thought's Head-Wing Ideology, integration respects both left and right ideologies while transcending them. Conceptual coherence requires that integration occur within comparable categories; disparate conceptual domains risk incoherence when forcibly merged. Unity as "integration" implies recursive scaling: from personal (mind–body unity), to familial, societal, and global levels—a fractal-like expansion toward world peace.

2.3. Unification as Inclusion/Transcendence (Po-wol, 包越)

The neologism po-wol synthesizes inclusion and transcendence, allowing selective absorption of compatible elements while discarding contradictions. It operates both vertically (developmental stages as in Maslow or Erikson) and horizontally (cultural evolution across time). Philosophically, po-wol is akin to dialectical integration, preserving prior value while ascending to higher synthesis. Ken Wilber's Integral Theory exemplifies this approach: each stage transcends and includes the previous, processing through awareness quadrants toward integrative consciousness. In socio-political terms, po-wol offers a model for reconciling North–South Korean systems: retaining strengths of each while reconstructing a transcendent unity.

2.4. Unity as Holistic Integration (Tongjeon, 統全)

Unlike technical synergy or mechanical combination, tongjeon refers to ontological wholeness. It introduces theological integrity, opposing dogmatic fragmentation and sectarianism. Borrowing from integrative theology, it defines integration as an epistemic attitude of openness to universal truth and mutual enrichment. Tongjeon maintains that integration is a value-generating process, not merely a compromise. Through it, even theological binaries such as Christ's divinity and humanity are reconciled—not via reduction, but through a holistic logic that reflects the unity of opposites.

3. Mechanisms of Unification Methodology

3.1. Jeong-Boon-Hap: Affirmation, Differentiation, Integration

The Unification Thought reformulates Hegelian dialectic into a threefold mechanism: Jeong (Affirmation) refers to initial recognition of truth or standpoint, Boon (Differentiation) to acknowledgment of contradiction or difference, and Hap (Integration) to Creative synthesis into a new higher-order unity.
This method overcomes the adversarial model of Marxist dialectics. Grounded in give-and-receive action, Jeong–Boon–Hap fosters purposive unity and sustainable cooperation within social and interpersonal dynamics. It becomes a mechanism of organic development, promoting mutual respect and relational equilibrium.

3.2. Wonhyo's Hwa-jaeng (Philosophy of Harmonizing Disputes)

Wonhyo's hwa-jaeng philosophy (和諍) arose to reconcile sectarian Buddhist schisms by focusing on ilshim (一心, one mind). All doctrinal expressions are manifestations of a single truth, distorted by linguistic dualism. Hwa-jaeng encourages non-attachment to any single system and underscores the relationality of all views. In geopolitical or ideological integration, hwa-jaeng is invaluable. Its emphasis on mutual rootedness, relational ethics, and non-dual understanding enables diverse elements (e.g., North–South beliefs) to harmonize based on shared ontological value.

3.3. Unification via Heartistic Hermeneutics

Heartistic hermeneutics proposes an alternative to both deterministic and relativistic approaches. While E.D. Hirsch's author-centered model seeks stable meaning, and Roland Barthes' reader-centered model emphasizes textual openness, heartistic interpretation aims for relational unity—seeking the original intent, heart, and context of the text or idea. In Unification Thought, understanding is achieved when interpreter and originator become attuned in heart and consciousness. This hermeneutic empowers mutual empathy, bridging ideological gaps and creating psychological-spiritual unification.

4. Conclusion

This study positions the concept of unification not as abstract idealism but as a structurally and practically attainable paradigm. The mechanisms of integration, inclusion/transcendence (po-wol), and totality (holistic unity) offer a multi-dimensional framework. Concretely, the methodologies of Jeong–Boon–Hap, Hwa-jaeng, and heartistic hermeneutics function as tools to operationalize unification on individual, societal, theological, and global levels. True unification—as proposed in Unification Thought—is not coercive amalgamation but a value-

centered harmonization of mutually receptive elements. It is a spiral process of internal change extending outward to transform families, society, nations, and ultimately, the world.

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Interreligious Dialogue for Peacebuilding: A Hermeneutical-Philosophical Approach to the Ethics of Understanding in a Post-Conflict Africa

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Abstract: This article explores interreligious dialogue as a key tool for peacebuilding in post-conflict African societies. It employs a hermeneutical-philosophical lens to advocate for an ethics of understanding as the basis for healing and reconciliation. Drawing on the philosophical perspectives of Hans-Georg Gadamer and African ethical traditions, the study highlights how dialogical engagement across religious and cultural lines can foster mutual recognition and restore dignity to affected communities. It emphasizes the importance of narrative, memory, and meaning in shaping interreligious ethics. By advancing a transformative approach to dialogue, the article challenges instrumental views of religion and calls for deeper epistemological shifts in peacebuilding practices on the continent.

Keywords: Interreligious Dialogue, peacebuilding, hermeneutics, African philosophy, ethics

1. Introduction

1.1. Context of post-conflict Africa and the need for sustainable peace

In the wake of violent conflicts across the African continent—whether driven by ethnic tensions, political instability, or religious extremism—there has been an urgent call for frameworks that facilitate sustainable peace. Post-conflict societies such as Rwanda, South Sudan, the Central African Republic, and parts of Nigeria highlight the deep scars left by violence, dislocation, and mistrust. Healing such fractures requires more than legal and political measures; it necessitates moral and cultural interventions that rehumanize the other and restore intercommunal trust [1]. To achieve sustainable peace, it is essential to integrate cultural and religious dimensions into the reconstruction process. These dimensions are often marginalized in peace agreements that focus primarily on political power-sharing or economic recovery. Yet, religious communities remain influential in shaping societal values and have unique capacities to mediate tensions through their ethical teachings and community structures [2]. By centering these resources, post-conflict societies can address not only the structural but also the relational and symbolic wounds of violence. Moreover, peacebuilding must contend with the psychological aftermath of violence, including trauma, suspicion, and the erosion of moral imagination. Philosophical and theological approaches—especially those grounded in African worldviews—offer valuable perspectives for reconstituting relationships. Such approaches prioritize healing, justice, and social harmony, thereby complementing juridical and diplomatic efforts [3]. Sustainable peace in Africa, therefore, is best understood as a holistic, multidimensional process that must engage ethical, spiritual, and interpretive resources.

Finally, the African experience of conflict often features a religious dimension, either as a contributing factor or as a potential solution. In many instances, religious identities are mobilized for division, but they can also be reoriented toward reconciliation and mutual recognition. This dual potential of religion necessitates careful attention to the interpretive frameworks that guide interreligious relations [4]. Understanding religion's ethical capacity in peacebuilding contexts is thus indispensable for Africa's post-conflict recovery.

1.2. Overview of interreligious dialogue as a peacebuilding tool

Interreligious dialogue refers to intentional, respectful engagement between people of different faiths to promote understanding, trust, and cooperation. In African post-conflict societies, where religious pluralism often

intersects with ethnic and political divisions, such dialogue becomes crucial for preventing the reoccurrence of violence and building inclusive communities. It provides a moral space in which shared values like compassion, justice, and human dignity can be rediscovered and rearticulated [5].

This form of dialogue does more than promote peaceful coexistence; it can actively counteract narratives of exclusion and hatred. Through shared storytelling, theological reflection, and joint action, religious groups can transcend historical grievances and participate in collective healing. Furthermore, interreligious dialogue often re-establishes trust between communities and institutions, which is vital for rebuilding social capital in the aftermath of war or genocide [6].

In the African context, religious leaders and institutions have historically played a role in peacemaking—from the interfaith councils in Kenya and Sierra Leone to the work of the Interreligious Council of Uganda. These initiatives demonstrate how interreligious dialogue can support transitional justice and provide platforms for restorative encounters [7]. When properly grounded in mutual respect and hermeneutical openness, such dialogue can serve as a transformative force in societies fractured by religious or political violence.

Crucially, the ethics of interreligious dialogue must be rooted in sincerity, equality, and recognition of the other's humanity. It cannot be a superficial or instrumental exercise; rather, it must involve a genuine openness to learning from the other's perspective. This requires a philosophical framework that values interpretation, narrative, and empathy—dimensions often neglected in political peacebuilding strategies [8]. Hence, dialogue should be both a moral imperative and a strategic necessity in peacebuilding discourse.

1.3. Statement of purpose: advocating for an ethics of understanding using a hermeneutical-philosophical approach

This article proposes a hermeneutical-philosophical framework for understanding interreligious dialogue as an ethical and transformative response to conflict in Africa. Drawing on Hans-Georg Gadamer's hermeneutics and African philosophies such as ubuntu, the article argues that the ethics of understanding—rooted in dialogue, interpretation, and mutual recognition—is essential for building peace in post-conflict contexts. This approach challenges instrumentalist and pragmatic uses of religion and instead highlights the dialogical encounter as an ethical event [9].

The goal is not merely to promote tolerance, but to encourage an epistemological shift in how communities relate across religious divides. This involves reimagining peacebuilding as a process that values listening, humility, and narrative hospitality. The ethics of understanding presumes that genuine dialogue transforms both participants, fostering shared meaning and restoring fractured social bonds [10]. In this sense, dialogue is not only a method but also a moral posture. By situating peacebuilding within a hermeneutical-philosophical paradigm, the article seeks to deepen scholarly and policy conversations around religion and conflict. It invites practitioners to go beyond traditional diplomacy or security frameworks and embrace interpretive, relational, and ethical practices rooted in both African and global philosophies. Ultimately, the article advocates for a deeper engagement with the moral and epistemic conditions that make genuine peace possible [11].

This approach is especially timely as many peacebuilding efforts in Africa remain disconnected from the spiritual and cultural resources of the communities they aim to serve. The ethics of understanding offers a way to reclaim these resources while promoting reconciliation rooted in justice and human dignity. It urges scholars, faith leaders, and policymakers alike to take seriously the transformative potential of dialogue as both philosophy and practice [12].

2. Theoretical Framework

2.1. Hermeneutical Philosophy of Hans-Georg Gadamer

Hans-Georg Gadamer's [9] philosophical hermeneutics centers on the idea that understanding is not merely a technical process but a dialogical event. At the heart of his theory is the concept of the "fusion of horizons," where interlocutors bring their distinct perspectives into dialogue, and through mutual engagement, arrive at deeper, shared meaning [9]. This process is rooted in openness, tradition, and the transformative power of language, making it highly relevant for post-conflict contexts marked by division and mistrust. Gadamer's hermeneutics challenges the notion that understanding others can be achieved through detached objectivity. Instead, it affirms

that understanding emerges from historically situated dialogue, where prejudices (in the non-pejorative sense) shape and enrich the process of meaning-making. This aligns with African oral traditions, where intergenerational narratives and moral discourses are central to conflict resolution and identity formation [13]. By foregrounding interpretation, Gadamer offers a model for interreligious dialogue that is dynamic, open-ended, and ethically charged.

In post-conflict Africa, where identities have been politicized and weaponized, Gadamer's insights offer a way to rebuild trust through dialogical engagement rather than coercive or performative reconciliation. His emphasis on conversational ethics—where the goal is not victory but understanding—resonates deeply with African communal philosophies that prioritize social harmony and collective flourishing [14]. Hermeneutics thus becomes a bridge between philosophical traditions and practical peacebuilding. Furthermore, Gadamer's work provides a philosophical counterpoint to technocratic peacebuilding approaches that neglect the symbolic and affective dimensions of healing. His theory insists on the importance of narrative, ritual, and shared language in reconstructing communal life. In societies traumatized by war, such elements are essential for restoring meaning and belonging. Hermeneutics thereby offers not only a method but a moral vision of reconciliation [15].

2.2. African Ethical and Philosophical Traditions

African philosophical traditions provide rich resources for an ethics of peace and reconciliation. Central among these is *ubuntu*, an ethical worldview that emphasizes the interconnectedness of all people—"I am because we are." Ubuntu rejects individualism and affirms the community as the foundation of moral life. It advocates for empathy, mutual care, and justice as the basis for human dignity and social restoration [16]. This aligns closely with post-conflict needs for healing, rehumanization, and inclusive dialogue. In addition to ubuntu, African ethics emphasizes *communalism*, where identity is embedded within relational networks. Conflicts are not seen as isolated incidents but as disruptions of communal equilibrium that require collective response. The goal is not punishment but the restoration of social harmony through truth-telling, forgiveness, and reparative action [17]. This restorative model has influenced transitional justice mechanisms such as Rwanda's *gacaca* courts, which incorporated public confession and community participation.

Moreover, African traditions frame justice as relational rather than retributive. Unlike Western legal models that prioritize abstract rights and procedural fairness, African justice systems often prioritize reconciliation, compensation, and reintegration of offenders into the community. This ethical orientation supports a dialogical approach to peacebuilding that privileges listening, mediation, and moral accountability over punitive measures [3]. Thus, African philosophies provide both conceptual and practical foundations for interreligious peace dialogue. These traditions also value intersubjectivity—the recognition that each person's humanity is affirmed through the humanity of others. In contexts of religious conflict, this principle fosters the ethical imperative to see the other not as a threat but as a mirror of one's own dignity and vulnerability. In this way, African ethical systems contribute profoundly to a hermeneutics of peace rooted in empathy, relational identity, and moral responsibility [18].

3. Ethics of Understanding in Interreligious Dialogue

3.1. Concept of "ethics of understanding" as a foundation for genuine peace

The concept of an "ethics of understanding" calls for a moral framework rooted in dialogical engagement, mutual respect, and the pursuit of meaning across religious and cultural lines. In post-conflict African societies, where trauma and mistrust linger, peacebuilding efforts must transcend legalistic or superficial agreements and delve into the human capacity for empathetic interpretation. Drawing from Hans-Georg Gadamer's hermeneutics, understanding becomes not merely cognitive but ethical—a willingness to encounter the Other in their difference and to remain open to transformation through dialogue [9]. This ethical orientation shifts the peacebuilding paradigm from one of control or management to one of transformative relationship-building. As Palmer [19] notes, genuine understanding arises not from the imposition of one's worldview but from a shared space where different narratives coexist and interact. Such an ethics enables participants to see the Other not as a threat or a

project but as a co-bearer of meaning and humanity. It foregrounds a moral responsibility to engage difference without prejudice or domination.

In African contexts, where colonial and postcolonial disruptions have deeply affected religious and cultural cohesion, the ethics of understanding becomes particularly crucial. Wiredu [13] argues that African philosophical traditions emphasize consensus and communal dialogue as essential modes of ethical life. By anchoring peacebuilding in dialogical ethics, interreligious initiatives can draw from indigenous wisdom to reestablish bonds of trust and shared purpose. This synergy between African ethics and hermeneutics fosters a peace rooted in lived experience, not imposed agendas.

Furthermore, the ethics of understanding challenges the reduction of religion to identity politics or utilitarian agendas in conflict zones. It seeks to restore the moral and existential depth of religious life, reminding communities that faith can be a site of healing and reconciliation. As Appleby [4] emphasizes, religious actors, when guided by ethical principles of understanding, can contribute profoundly to the moral reconstruction of society.

3.2. The role of listening, empathy, and openness in interfaith encounters

Listening, empathy, and openness form the bedrock of meaningful interreligious dialogue. These virtues are not passive dispositions but active practices that involve suspending judgment, entering into the world of the Other, and allowing oneself to be reshaped by the encounter. In post-conflict settings, where wounds run deep and suspicion abounds, such ethical engagement is indispensable for genuine reconciliation [20]. Philosophically, this ethos of empathetic listening aligns with Gadamer's notion of the "fusion of horizons," which requires each participant in dialogue to relinquish the certainty of their perspective in pursuit of mutual understanding [9]. This hermeneutical openness is both epistemological and moral, demanding vulnerability and respect. In African societies, such relational virtues are echoed in the communal principle of *ubuntu*, which affirms that a person becomes a person through others [17].

Empathy also serves as a counter to the dehumanization that often accompanies interreligious violence. By humanizing the Other and recognizing their suffering, dialogue participants enact a form of ethical solidarity that transcends doctrinal differences. As Lederach [21] argues, sustainable peace requires not only political settlements but also moral imagination—the capacity to imagine and feel what the Other experiences, thus creating a space for healing and shared future-making.

In practical terms, interfaith initiatives must cultivate environments where listening is institutionalized as a spiritual and ethical discipline. This includes training leaders and communities in dialogical skills, creating safe spaces for expression, and prioritizing relational over strategic goals. When these practices are rooted in empathy and openness, interreligious dialogue becomes a transformative force in post-conflict peacebuilding [8].

3.3. Contrast with instrumental and superficial approaches to religion in peace processes

Too often, religion is approached instrumentally in peacebuilding efforts—as a source of legitimacy, a channel for political messaging, or a mechanism for social control. Such superficial engagement treats religious leaders and communities as tools rather than as moral agents, thereby undermining the depth and richness of religious life. This reductionist view can exacerbate tensions by reinforcing sectarian identities instead of addressing the deeper spiritual and ethical dimensions of conflict [7].

In contrast, a hermeneutical-philosophical approach calls for a more profound engagement with religion—not merely as a system of beliefs, but as a lived horizon of meaning. This requires recognizing that faith traditions possess internal resources for peace, forgiveness, and justice that cannot be accessed through external manipulation alone. As Tutu [16] demonstrated in South Africa's Truth and Reconciliation Commission, religious frameworks can offer powerful narratives of healing when authentically engaged.

Superficial approaches also ignore the need for epistemic humility and ethical transformation in peacebuilding processes. When religion is instrumentalized, it often leads to performative dialogues that lack depth and sincerity. As Kadayifci-Orellana [22] warns, without a commitment to genuine understanding and relational healing, such dialogues may do more harm than good by entrenching power imbalances and silencing marginalized voices. To avoid these pitfalls, peace practitioners must adopt a deeper, ethics-driven approach to

religious engagement—one that centers understanding, mutual learning, and co-creation of meaning. Only then can interreligious dialogue serve as a vehicle for lasting peace rooted in human dignity and spiritual integrity [23].

4. The Role of Narrative, Memory, and Meaning

4.1. Importance of storytelling in African cultures for healing and identity

Storytelling plays a vital role in African cultures as a means of transmitting knowledge, preserving identity, and facilitating communal healing. In post-conflict societies, stories allow individuals and communities to process trauma, assert agency, and reconstruct shared narratives of belonging. Through oral traditions, songs, and testimonies, African storytelling offers a rich resource for interreligious dialogue that honors memory and opens pathways to reconciliation [24]. Narrative practices in Africa are deeply relational, often emphasizing collective over individual experience. This resonates with Gadamer's hermeneutics, which views understanding as historically and linguistically embedded. Storytelling thus becomes a dialogical act—an encounter between past and present, self and Other, aimed at generating new meanings. As Ngũgĩ wa Thiong'o notes, reclaiming indigenous narratives is essential for cultural and psychological decolonization [25].

In interfaith contexts, storytelling can help bridge theological divides by foregrounding lived experiences over abstract doctrines. When religious communities share their stories of suffering and resilience, they discover common ethical ground rooted in human vulnerability. This process fosters empathy and counters religious stereotypes that often fuel conflict. As Lederach [21] observes, peace emerges from the weaving together of personal and communal narratives into a moral tapestry of hope.

Furthermore, storytelling empowers marginalized voices that are often excluded from formal peace negotiations. Women, youth, and minority groups can use narrative as a tool of resistance, healing, and political assertion. By incorporating storytelling into interreligious dialogue, peacebuilders can ensure a more inclusive and emotionally resonant process—one that acknowledges pain, affirms identity, and gestures toward shared futures [26].

4.2. Memory as a space for moral reflection and reconciliation

Memory in post-conflict societies is not merely a record of past events but a contested and moral terrain where communities grapple with questions of justice, accountability, and forgiveness. Interreligious dialogue that engages memory must therefore be attentive to the wounds of history, the politics of remembrance, and the ethical imperative to reckon with the past. As Ricoeur [27] argues, memory is both constructive and interpretive—it shapes identity and orients action.

In many African societies, communal remembrance rituals such as libation ceremonies, storytelling circles, and ancestral veneration serve as moral frameworks for reconciling with the past. These practices invite collective reflection and reaffirm the dignity of those who have suffered. When integrated into interfaith dialogue, such memory work creates a space where moral responsibility can be shared and healing initiated [28].

Memory also serves as a bulwark against historical amnesia, which can perpetuate cycles of violence. By naming injustices and honoring victims, religious communities play a vital role in fostering ethical accountability. Truth-telling, when framed within a spirit of reconciliation rather than vengeance, opens possibilities for moral regeneration. As Tutu [16] emphasized, remembering is a sacred act—one that grounds forgiveness in the recognition of pain and the affirmation of humanity. Importantly, dialogical memory resists the instrumentalization of history for sectarian purposes. It invites multiple perspectives and embraces ambiguity, thereby cultivating a more nuanced and compassionate understanding of the past. This hermeneutical approach to memory fosters humility and prepares communities to engage in peacebuilding with integrity and hope [19].

4.3. Meaning-making in religious traditions as a basis for shared values

Religious traditions are powerful sources of meaning-making that shape how individuals and communities understand suffering, justice, and peace. In interreligious dialogue, engaging these symbolic and moral worlds enables participants to discover shared values that transcend doctrinal differences. The act of interpreting sacred

texts and rituals through a hermeneutical lens can illuminate ethical commonalities essential for peacebuilding [29].

In African contexts, religious meaning is often deeply intertwined with social life, environmental stewardship, and community welfare. This holistic worldview aligns with the ethics of interdependence and mutual responsibility found in many African philosophies. By drawing on these resonances, interfaith dialogues can foster a sense of spiritual kinship and collective moral purpose [14].

Meaning-making also provides existential grounding for individuals grappling with the aftermath of violence. Through prayer, ritual, and theological reflection, religious communities help people make sense of suffering and envision a redemptive future. These practices cultivate resilience and hope, which are indispensable for peace and reconciliation. As Appleby [4] notes, religious meaning, when guided by compassion and justice, can inspire moral courage and social transformation.

Finally, shared values discovered through meaning-making can inform concrete peace initiatives—such as joint service projects, community rebuilding, and advocacy for justice. When religious communities find common ground in their visions of the good, they become agents of healing rather than antagonists. This transformation is only possible when dialogue moves beyond tolerance to the deeper work of interpretive and ethical engagement [8].

5. Interreligious Dialogue as Transformative Practice

5.1. Beyond tolerance: toward mutual recognition and human dignity

The goal of interreligious dialogue must extend beyond mere tolerance to deeper forms of mutual recognition and affirmation of shared human dignity. Tolerance, while valuable as a first step, often implies a passive coexistence without genuine engagement or transformation. In contrast, mutual recognition involves acknowledging the other as an equal moral agent, worthy of respect and dialogical partnership. This shift transforms dialogue from a strategic engagement into a moral and spiritual encounter [12].

Mutual recognition requires a deconstruction of prejudices and assumptions that have historically shaped interfaith relations, particularly in post-colonial African contexts. According to Taylor [30], recognition is essential to identity formation; when one's religious identity is ignored or misrepresented, it leads to social and psychological harm. Interreligious dialogue thus becomes a vehicle for restoring dignity, particularly among marginalized or demonized faith groups. Through honest engagement, communities begin to see one another not as threats but as partners in peacebuilding.

In African philosophies, the ethic of *ubuntu* reinforces this orientation. *Ubuntu* posits that one's humanity is realized in and through the humanity of others—*"I am because we are."* This ethical grounding makes mutual recognition a communal, rather than individual, imperative. Interfaith dialogue rooted in *ubuntu* creates spaces where diverse communities affirm each other's sacred worth, leading to social cohesion and moral solidarity [31]. By emphasizing mutual recognition, dialogue shifts from transactional coexistence to relational transformation.

5.2. Case examples or theoretical illustrations of transformative dialogue

Transformative interreligious dialogue is exemplified in several African initiatives that have prioritized healing and reconciliation. One prominent case is the Interfaith Mediation Centre in Kaduna, Nigeria, co-founded by Imam Muhammad Ashafa and Pastor James Wuye. These former adversaries turned peacebuilders model how dialogue, when grounded in repentance, forgiveness, and mutual learning, can dismantle long-standing hostilities. Their story demonstrates the capacity of faith-based dialogue to rehumanize the Other and rebuild broken relationships [32].

The South African Truth and Reconciliation Commission (TRC) also illustrates how religious frameworks can inform transformative dialogue. Archbishop Desmond Tutu's leadership infused the TRC with Christian notions of forgiveness, justice, and confession, while also honoring African traditions of truth-telling and restorative justice. The TRC was not a perfect process, but it created a moral space where victims and perpetrators could share their stories and envision a reconciled future [16]. This dialogical model integrated narrative, ritual, and ethical reflection in ways that transcended mere policy.

Theoretically, transformative dialogue draws from Paulo Freire's [33] notion of *conscientization*—a deepening of awareness that leads to moral agency and social change. When applied to interreligious engagement, this means moving from surface-level understanding to a critical interrogation of power, history, and shared values. Transformative dialogue is not merely about doctrinal agreement but about forging new ethical possibilities and communal imaginaries. It recognizes that peace is not the absence of conflict but the presence of justice, empathy, and collective vision.

5..3. Dialogue as a process of epistemological and ethical reorientation

True interreligious dialogue demands a rethinking of how knowledge and ethics are constructed—what Gadamer [9] called a "fusion of horizons." Participants must enter dialogue with the humility to recognize the partiality of their own perspectives and the legitimacy of others' epistemic worlds. This epistemological shift is foundational for ethical reorientation, as it moves individuals and communities toward deeper moral sensitivity and intellectual openness.

In African contexts, this involves bridging Western philosophical models with indigenous ways of knowing, which often emphasize relationality, oral tradition, and the sacredness of life. As Higgs [34] argues, indigenous African epistemologies offer holistic frameworks that integrate emotion, spirituality, and community, countering the hyper-rationalist tendencies of Western thought. Interfaith dialogue that honors these epistemologies becomes an act of decolonization and ethical renewal.

Moreover, this reorientation calls into question the binaries that have historically separated sacred from secular, faith from reason, and tradition from modernity. It instead fosters a dialogical imagination that can hold multiple truths in tension, enabling communities to co-create moral visions for the future. Such ethical pluralism does not mean relativism but a commitment to learning from difference and allowing the Other to become a teacher. In doing so, interreligious dialogue becomes not a compromise of truth but a deeper journey into it [8].

6. Critique of Instrumentalist Views of Religion

6.1. Examination of how religion is often used as a tool or obstacle in peacebuilding

Religion is frequently instrumentalized in peacebuilding as either a convenient tool for political mobilization or a scapegoat for conflict. This reductionist approach overlooks the complexity and depth of religious traditions, framing them as either inherently violent or inherently peaceful. Such binary thinking fails to account for the contextual factors—economic, political, and historical—that shape religious expressions and identities [35].

When religion is treated merely as a means to an end, its ethical and spiritual potential is compromised. Governments and NGOs may co-opt religious leaders for legitimacy, expecting them to pacify communities without addressing root causes of conflict. This manipulative use of religion undermines the authenticity of religious engagement and may deepen mistrust among communities. As Mahmood [36] warns, instrumentalism often renders religious actors passive agents in externally driven agendas, stripping them of agency and voice.

Furthermore, this approach can ignore intra-religious dynamics and the contested nature of religious authority. Not all religious actors speak with one voice, and conflicts within traditions can be as significant as those between them. Effective peacebuilding must therefore engage religion not as a monolith but as a plural and dynamic force. Recognizing this complexity allows for a more nuanced and respectful partnership between religious and secular actors in post-conflict reconstruction [4].

6.2. Dangers of politicization and reductionism in religious discourse

Politicizing religion involves framing theological doctrines or religious identities as instruments for achieving political goals. This strategy is often employed by elites to consolidate power, marginalize opposition, or incite divisions. In the African context, such politicization has fueled sectarian tensions, exacerbated ethnic divides, and undermined the credibility of religious institutions. By collapsing religious and political identities, this practice erodes the spiritual autonomy of faith communities [7].

Reductionism compounds this problem by portraying religion in simplistic and essentialist terms. Media and policy discourse often reduce Islam, Christianity, or African Traditional Religions to monolithic ideologies,

ignoring the diversity within each tradition. This leads to stereotypes that distort public perception and hinder genuine dialogue. As Said [37] cautioned in his critique of Orientalism, such reductive portrayals serve political agendas and hinder cross-cultural understanding.

The ethical consequences of politicization and reductionism are severe. They delegitimize religious voices that seek peace, exacerbate identity-based violence, and entrench mistrust among communities. Interreligious dialogue must actively resist these tendencies by promoting critical reflection, historical consciousness, and theological depth. Only by recovering the richness and plurality of religious traditions can dialogue become a force for ethical renewal and social healing [8].

6.3. Call for a paradigm shift in how religion is engaged in public and peacebuilding spheres

To overcome these limitations, a paradigm shift is needed—one that repositions religion not as a tool but as a partner in the moral reconstruction of society. This shift involves engaging religious traditions on their own terms, with respect for their internal logic, ethical teachings, and spiritual insights. It also requires building relationships of trust and reciprocity between religious and secular actors, rooted in shared commitment to justice and dignity [38].

This paradigm shift must also be epistemological. Instead of viewing religion as an obstacle to modernity, peacebuilding frameworks should acknowledge its role in shaping moral imagination, social solidarity, and long-term commitment. As Casanova [39] argues, religion is not retreating from the public sphere but reemerging as a critical force in global ethics. Dialogue that incorporates this insight can harness the transformative capacities of faith for the common good.

Practically, this means redesigning peacebuilding programs to include religious voices from the start, ensuring theological literacy among practitioners, and supporting grassroots interfaith initiatives. It also entails a commitment to long-term engagement rather than event-based interventions. By making room for religion as a complex and constructive force, peacebuilding can become more holistic, inclusive, and contextually grounded [4,32].

7. Implications for Peacebuilding in Africa

7.1. Practical recommendations for policymakers, religious leaders, and educators

For peacebuilding to be sustainable in post-conflict African societies, stakeholders—including policymakers, religious leaders, and educators—must adopt a collaborative and ethically grounded approach. Policymakers should prioritize inclusive governance structures that institutionalize interreligious dialogue as part of peace processes. This could involve setting up national interfaith councils, creating mediation platforms, and funding community-level dialogue programs. State actors must recognize the moral and cultural authority of religious institutions and integrate them as partners in policymaking [40].

Religious leaders, on their part, have a moral obligation to transcend sectarian interests and champion peace as a theological imperative. They should invest in theological education that promotes peace, reconciliation, and pluralism. This includes critically reinterpreting sacred texts in ways that affirm human dignity and nonviolence. Moreover, interfaith coalitions should be empowered to speak with a united voice against violence, corruption, and injustice, fostering moral clarity in divided societies [4].

Educators also play a transformative role by fostering interreligious literacy from early education through higher learning. Curricula should include components on comparative religion, conflict resolution, and ethics of dialogue. Schools can become laboratories for peaceful coexistence when students learn to appreciate religious diversity through structured exposure and reflective engagement. By equipping learners with dialogical skills, critical thinking, and empathy, education can serve as a long-term investment in social cohesion [41].

7.2. Integration of hermeneutical ethics in post-conflict reconstruction

The incorporation of hermeneutical ethics into post-conflict reconstruction processes offers a framework for deeper moral healing and inclusive justice. Rooted in the philosophical traditions of thinkers like Hans-Georg Gadamer, hermeneutical ethics emphasizes understanding through dialogue, reflexivity, and openness to the

Other [9]. Post-conflict processes such as truth commissions, reparations, and community healing forums can benefit from this approach by framing them not only as legal mechanisms but as spaces for ethical listening and mutual transformation.

In African societies, where oral tradition and communal narratives play a central role, hermeneutical ethics aligns with indigenous practices of restorative justice. The emphasis on storytelling, symbolic reconciliation, and ritual acknowledgment of harm resonates with many traditional African conflict resolution models [3]. This suggests that reconstructive justice efforts should be culturally embedded and dialogically structured to reflect both philosophical and local ethical worldviews.

Furthermore, hermeneutical ethics offers an alternative to punitive or technocratic approaches that often dominate international peacebuilding interventions. Rather than focusing solely on outcomes, it prioritizes the moral quality of the process—how people are heard, acknowledged, and reintegrated. This orientation is vital in repairing broken relationships and restoring trust among religious and ethnic communities. It turns peacebuilding into a shared ethical journey rather than a top-down policy prescription [21].

7.3. Cultivating interreligious literacy and dialogical competence

Interreligious literacy is essential in a continent as religiously plural as Africa, where misunderstanding and manipulation of religious difference have often fueled conflict. Interreligious literacy entails more than factual knowledge of other faiths; it involves developing attitudes of respect, curiosity, and ethical responsibility. Individuals must learn how to navigate religious difference without resorting to relativism or superiority. This competence is particularly important for those in leadership positions—political, educational, and spiritual [42].

Dialogical competence builds on this literacy by equipping individuals with the skills to engage in constructive, respectful, and transformative conversations. These include active listening, empathy, nonviolent communication, and the capacity for critical reflection. Institutions such as universities, seminaries, and civic organizations can play a central role in fostering these competencies through workshops, interfaith exchanges, and community dialogues [8]. Religious institutions, in particular, must model dialogical ethics in both internal and external relations.

Equipping future generations with these skills also serves a preventive function, making societies more resilient to extremist ideologies, religious nationalism, and xenophobia. It builds social capital by strengthening trust across difference. Over time, dialogical competence creates the cultural infrastructure necessary for peace to be sustained—not merely through treaties or institutions but through everyday interactions. This human infrastructure is the most durable defense against conflict [32].

8. Conclusion

8.1. Summary of key arguments

This article has explored how interreligious dialogue, framed through a hermeneutical-philosophical lens, can serve as a vital tool for peacebuilding in post-conflict African societies. It emphasized the ethical dimension of dialogue—not just as a strategic engagement, but as a transformative practice rooted in empathy, recognition, and shared meaning. Drawing from both African ethical traditions and the thought of Hans-Georg Gadamer, the study proposed an "ethics of understanding" as foundational for reconciliation, dignity, and sustainable peace.

The discussion highlighted the role of narrative, memory, and meaning-making in shaping interreligious ethics, demonstrating how African storytelling traditions and religious rituals can contribute to healing and moral regeneration. By advancing a dialogical and interpretive approach, the article critiqued superficial or instrumental uses of religion in peacebuilding and called for a paradigm shift in how religion is understood and engaged in public life. It also offered practical recommendations for various stakeholders, from policymakers to educators, aimed at embedding dialogical ethics in peacebuilding initiatives.

In sum, interreligious dialogue must be approached not as an optional add-on to peace processes, but as a moral and philosophical necessity. When grounded in mutual recognition and epistemological humility, such dialogue can rebuild fractured relationships, restore communal trust, and foster a culture of peace that is both

ethical and enduring. Its transformative power lies not in erasing difference, but in embracing it as a source of moral insight and relational depth [8,21].

8.2. Reiteration of interreligious dialogue as a pathway to ethical peace

The ultimate value of interreligious dialogue lies in its capacity to generate ethical peace—peace that is not merely the absence of violence, but the active presence of justice, reconciliation, and human flourishing. This vision of peace cannot be engineered through diplomatic negotiations or institutional reforms alone. It requires a transformation in how people understand and relate to one another across religious boundaries. It demands that societies cultivate empathy, listen across difference, and foster relationships that dignify all parties involved [21].

In African contexts, where religion is deeply woven into social, political, and cultural life, such dialogue is especially urgent. Faith communities possess vast resources for healing, truth-telling, and moral imagination. By engaging these resources ethically and dialogically, post-conflict societies can address historical grievances, prevent future violence, and build inclusive communities. As Appleby [4] notes, the ambivalence of the sacred means religion can fuel both peace and conflict—thus, the challenge is to harness its constructive power through ethical engagement.

The ethics of understanding proposed in this study offers a way forward. It invites all parties—religious and secular, African and global—to rethink peace not as a technocratic solution but as a relational, moral, and hermeneutical process. Interreligious dialogue becomes a pedagogy of peace, teaching individuals and communities to see, listen, and act with integrity. Such dialogue has the potential to turn post-conflict transitions into genuine moral transformations.

9. Future research and policy directions

Future research should further explore how hermeneutical and African ethical frameworks can inform interreligious peacebuilding in different African regions. Comparative studies between nations or case studies on grassroots initiatives could illuminate best practices and context-specific challenges. Moreover, interdisciplinary work combining theology, philosophy, anthropology, and peace studies would deepen the conceptual grounding of dialogical ethics and strengthen its applicability in policy contexts [41].

Policy directions should prioritize capacity building for interfaith leaders, institutionalize interreligious engagement in peace processes, and incorporate interreligious ethics into national education curricula. Governments, NGOs, and religious organizations must collaborate to build frameworks that support long-term, community-driven dialogue. This includes not only funding and logistics but also ethical oversight and cultural sensitivity [38].

Finally, more attention must be given to youth engagement. Africa's youthful population represents both a challenge and an opportunity. Empowering young people with interreligious literacy, dialogical competence, and moral leadership skills can change the trajectory of entire societies. Through education, mentorship, and digital engagement, a new generation of peacebuilders can emerge—equipped not only with knowledge but with the ethical orientation needed to build just and peaceful futures.

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An Understanding Carl Rogers' Human Nature From the Perspective of Unification Thought's Theory of Original Human Nature

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Abstract: This study analyzes Carl Rogers' theory of human nature based on the theory of original human nature from Unification Thought. It aims to clarify both the similarities and differences between these theories to propose an integrated approach to understanding human nature. Unification Thought regards humans as beings created in the image of God and explains human nature through four elements: Heart, Logos, Creativity and Positionality. Although human nature has been distorted by the Fall, it retains intrinsic goodness and the potential for restoration. In contrast, Carl Rogers defines humans as organismic beings striving for self-actualization, viewing human growth and self-actualization as processes driven by autonomous internal tendencies.

Both theories positively assess human nature and emphasize its potential for growth. However, they fundamentally differ in their perspectives on the origin of human nature, causes of its distortion, methods for restoration, and ultimate goals. While Rogers focuses on personal integration and individual growth, Unification Thought adopts a theological and teleological perspective that seeks both personal and communal integrated growth. Thus, Rogers' theory requires complementary theological approaches for practical application. This study suggests the integrated applicability of Unification Thought and Rogers' theory in counseling, recommending further research to develop concrete models for counseling.

Keywords: Unification Thought, Carl Rogers, Human Nature, Self-Actualization

1. Introduction

Modern society, despite its material abundance, is paradoxically witnessing a rise in psychological emptiness and inner conflict. As a result, the number of patients visiting psychiatric clinics continues to increase. As a psychiatrist, I have accumulated extensive research and clinical experience in healing patients suffering from mental distress. However, I have often found that the existing theories of counseling psychology alone do not provide sufficient satisfaction in therapeutic consultations. One reason for this is that many of the traditional counseling theorists developed their frameworks without a clear understanding of the existence of the God—our True Parents—and the divine purpose for human beings. Against this backdrop, this study aims to reexamine Carl Rogers' theory of human nature—known for its respect for human dignity—through the lens of the theory of original human nature in Unification Thought, which systematizes the teachings of Rev. Sun Myung Moon and Dr. Hak Ja Han Moon, who clearly revealed God's purpose for the creation of humankind. This thesis seeks to clearly identify the similarities and differences between the two frameworks, and to explore how Rogers' client-centered counseling theory might be elevated into a counseling approach centered on the God. Through this process, the study aims to explore the integrative applicability of Unification Thought and Rogers' counseling theory within therapeutic practice, thereby contributing to the expansion of the theoretical foundation for counseling and spiritual healing.

This thesis is primarily based on a theoretical comparative analysis using literature review, supported by philosophical interpretation and conceptual comparison. The human view of Unification Thought was analyzed through Outline of the Unification Thought [1] by the Unification Thought, and other related texts. In the literature review, Carl Rogers' key works and scholarly articles were examined to structure and understand his view of humanity. Next, the commonalities and differences between the two theories were analyzed using a

conceptual framework based on their philosophical backgrounds, teleology, and ethical perspectives. Finally, the study goes beyond a mere comparative listing of theories to qualitatively analyze the significance and implications of Unification Thought's theory of original nature in relation to Rogers' humanistic perspective.

The following prior studies are noteworthy:

Lee Ji-hyun, in A Buddhist Interpretation of Person-Centered Counseling, compares Buddhist and Rogers' views of human nature, arguing that both have complementary theoretical backgrounds [2].
Kim Eun-hee, in A Christian Review of Carl Rogers' Understanding of Human Nature and Counseling Theory [3], compares Rogers' view of human nature with various Christian counseling perspectives, emphasizing the importance of a biblical view of humanity while incorporating useful elements of Rogers' theory.
Kim Hee-sun, in A Study on the Understanding of Human Nature – Focused on Unification Thought and Jungian Psychology [4], finds that both Unification Thought and Jungian psychology aim to discover the God within the human being through the process of individuation and personal maturity.
Michiya Inada, in A Study on Viktor Frankl's Concept of Responsibility – Centered on the Viewpoint of the Divine Principle [5], compares Frankl's view of human responsibility with that of the Divine Principle, seeking ways to help people discover meaning in life and live in a more humane and value-centered manner.

2. Understanding the Theory of Original Human Nature in Unification Thought

Unification Thought offers a comprehensive framework that integrates perspectives from religion, philosophy, and cutting-edge science to provide ideological and philosophical proposals for creating a better world. It encompasses various disciplines, including the Theory of the Original Image, which addresses the nature of the God; Ontology, which explores the modes of existence of all things; and the Theory of Original Human Nature, which investigates the essential nature of the ideal human being. Unification Thought explains the created world through a deductive method based on the theory of creation—that all things were created according to the intention of the Creator, the God, in His image. The philosophical foundation of Unification Thought begins with the understanding that all beings, including the God and all created entities, exist in dual characteristics: **Sungsang and Hyungsang (internal and external character)** and **Yang and Yin**. **Sungsang** corresponds to the mind of the Creator—for human beings, this means the mind; for animals, instincts—representing invisible and functional aspects. **Hyungsang** corresponds to the body of the Creator, referring to the fundamental material aspect that forms the physical world. The dual characteristics of **yang and yin** are not substantial in themselves but are relative concepts, subordinate to the dual characteristics of **Sungsang and Hyungsang**.

Human beings, therefore, exist as beings of dual characteristics—mind and body—and from the perspective of yang and yin, males express more yang aspects, while females express more yin aspects [6].

In Unification Thought, human nature does not merely refer to innate tendencies or temperament but signifies an essential mode of existence directly connected to the Creator's purpose of creation. Unification Thought understands the human being as created in the image of the God (Genesis 1:27). This does not refer merely to external resemblance but to the reflection of the internal nature—**Sungsang**—of the God. Humans are beings who inherit the **intellect, emotion, and will** (知情意) from the God. More importantly, they inherit the **Heart** (*Shimjeong*, 心情)—defined in Unification Thought as "the core of the Sungsang, the emotional impulse that seeks joy through love" [6]. Therefore, human beings are inherently endowed with the **desire and capacity to love**, **relational orientation**, and **moral agency**. This understanding views human beings as fundamentally **good**—beings who seek to love others and live in harmony with them.

Minji Kim introduces the theory of original human nature in Unification Thought as a framework for answering the question, "What is a human being?"[7] Unification Thought analyzes human nature through four major elements. These elements concretize the premise that human beings resemble the nature of the God. **First**, human beings are emotional beings who resemble the God. As mentioned earlier, Heart (Shimjeong) is the core of divinity and the center of human nature. The more deeply one experiences the Heart of the God—who has poured out love upon humankind—the more one is filled with the inner impulse to love others and all things. This Heart becomes the fundamental motivation behind all human actions and ways of life. Because Heart is the core of

human character, being an emotional being also means being a personal and relational being. When the Heart to love others serves as motivation, intellect, emotion, and will are activated, leading the person to pursue truth, beauty, and goodness. A person centered on Heart becomes a moral agent capable of discerning good from evil, making ethical decisions, and taking responsibility [6].

Second, human beings are Logos-based beings who resemble the God. Logos is a Greek term meaning "word," "ideal," "principle," or "order." In ancient Greek philosophy, it was understood as the rational principle that structures the universe. In John 1:1, it says, "In the beginning was the Word (Logos)," indicating that the universe was created through the Logos. Unification Thought actively embraces this concept, placing Logos at the center in explaining the inner structure of the God and the principle of creation. Human beings were created by the God in closest resemblance to Him, according to the Logos. Thus, humans possess the rationality and lawfulness of the God. The features of reason and lawfulness in human beings are freedom and necessity. Therefore, humans are both rational beings who act according to free will and normative beings who follow laws and principles. In their original state, human beings were to act in accordance with freedom that naturally aligns with laws and norms. However, due to the Fall, they began to mistake unrestrained behavior for freedom, thereby deviating from proper norms [6].

Third, the God created the universe through creativity, and entrusted the final stage of creation—the fulfillment of the Three Great Blessings (Genesis 1:27)—to the first human ancestors. Through this process, He intended to recognize human beings as co-creators of the universe. Because creativity was bestowed upon humanity, Unification Thought asserts that humans are creative beings. The most essential form of creativity given to human beings is the creativity to fulfill the Three Great Blessings. At the heart of this lies the formation of a married couple—a union of a man and a woman who resemble the God. Abe Yoko and Kim Insoo describe the significance and value of such a perfected couple as: a manifestation of the God, the completion of the creation of the universe, the unification of humankind, and the fulfillment of the ideal family [8]. Perfecting one's character, becoming one in marriage, giving birth to new life, forming families grounded in both freedom and norms, and developing science and technology to govern the natural world—all these are core aspects of human creativity aimed at building heaven on earth [6].

The final aspect of human nature in Unification Thought is that human beings are "**beings of position**". A being of position refers to one who fulfills their role and responsibility according to a defined order and position. Human beings, having been created in the image of the dual characteristics of the God—specifically, the relationship between subject and object—possess both subject and object positions. The God, in the subject position, created human beings as His object partners to bring Him joy. In turn, human beings, as recipients of the God's love, come to love others and all creation from the subject position. This illustrates that position is not fixed, but changes dynamically depending on time and context—subject and object positions shift accordingly. Since human beings were created as children of the Creator, the God, they always exist in the object position before God. Therefore, a certain internal attitude—referred to as **"object consciousness"**—is required before the subject. Only those who maintain this object consciousness are qualified to assume the subject position toward others or the natural world [6].

Unification Thought holds that human nature is originally good, but has been distorted and suppressed due to the Human Fall. As a result, **Heart** (Shimjeong) has become self-centered, **character** has become egoistic, **creativity** has been misused destructively, and **awareness of position** has degenerated into authoritarian dominance. Thus, the restoration of original nature is not merely a matter of moral correction, but involves the **restoration of the relationship with the God**, the **restoration of Heart-centered living**, and the **restoration of the practice of true love**. Unification Thought understands human nature as a noble attribute inherited from the Sungsang of the God—especially the core of that Sungsang, which is Heart. Human beings, as recipients of the nature of the God, are beings who love others, live morally, create, take responsibility, and form good relationships with others. Though human nature has been damaged by the Fall, it is originally endowed with the potential for restoration and goodness. This perspective opens the door for dialogue with Carl Rogers' view of the self-actualizing person, and the significance of this dialogue will be further explored through comparison in Chapter 4.

3. Carl Rogers' View of Human Nature

Carl Rogers was born in 1902 in Illinois and grew up in a strict religious environment shaped by his parents' devout evangelical faith. Despite this setting, he developed a scientific way of thinking. He studied agriculture, history, and theology at the University of Wisconsin, but after a visit to China, he experienced a crisis of faith and decided to abandon his path to becoming a minister. He later earned a Ph.D. in child studies from Columbia University and, until his wife's passing, maintained a certain distance from religion. However, in his later years, he acknowledged the existence of a mysterious realm that could not be explained solely through scientific reasoning [9]. While serving as a professor at Ohio State University, Rogers argued that clients could resolve their own problems through a receptive and supportive therapeutic relationship. During his time at the University of Chicago, he further developed his core theory and published Client-Centered Therapy (1951), solidifying his position as a key figure in counseling psychology. He later served as president of both the American Psychological Association and the founding president of the American Academy of Psychotherapists. While at the University of Wisconsin, he authored the widely accessible On Becoming a Person: A Therapist's View of Psychotherapy (1961), which helped lead the Humanistic Psychology movement. In his final years, Rogers was active at the Western Behavioral Sciences Institute, applying his theories to social issues and contributing to conflict resolution efforts in areas such as Northern Ireland and South Africa. At the age of 85, he held a workshop in the Soviet Union, and in 1987, Carl Rogers passed away at the age of 85 [10].

3.1. Person-Centered Approach and the Actualizing Tendency

Carl Rogers' person-centered approach emerged in mid-20th century America, particularly after World War II, in the context of a society increasingly valuing individualism and autonomy. This period also saw a backlash against deterministic and pathology-centered views of human nature—such as those in psychoanalysis (Freud) and behaviorism (Watson, Skinner). The experience of human alienation caused by war, the Cold War, and industrialization prompted the question: "Are human beings essentially good and capable of growth?" Rogers' humanistic perspective offered a psychological and philosophical alternative to such questions [11].

Together with Abraham H. Maslow (1908–1970), Rogers is recognized as one of the founding figures of humanistic psychology. In contrast to first-generation psychology (psychoanalysis) and second-generation psychology (cognitive-behaviorism), which were often criticized for neglecting the inner self, subjectivity, and free will, humanistic psychology—known as the "third force"—aimed to restore the emphasis on human potential and autonomy. Rogers saw the human being as an organismic entity striving toward self-actualization, not merely as a subject of treatment but as a person capable of realizing their inner potential [12]. Rogers was philosophically influenced by existentialism and phenomenology. Existentialist thought, with its emphasis on individuality, subjective experience, and the importance of choice and responsibility, helped shape Rogers' therapeutic attitude of attentiveness to the client's subjective world. Under the influence of phenomenology, he understood humans not as objective entities but as experiencing subjects. This led to the development of non-directive counseling, which trusts the client's ability to arrive at the truth independently [13].

At the heart of Rogers' theory is the belief that humans possess an inherent, essential drive to actualize themselves—what he called the **actualizing tendency**. According to Rogers, human beings, as biological organisms, have an intrinsic tendency not just to survive but to grow, develop, create, and integrate themselves. This tendency is an inner, spontaneous energy, not driven by external instructions or control. Rogers saw this as the "most fundamental motivation within the human being [14]." This stands in contrast to Freud's concept of unconscious instincts or Skinner's theory of external conditioning. Instead, it is a theory rooted in a positive and growth-oriented view of human nature.

Rogers placed the self-concept at the center of human development. He distinguished between the real self (the true self that exists in present experiences) and the ideal self (an image shaped by others' expectations or societal norms). The degree of harmony between these two selves—called **congruence**—determines one's psychological health. Greater congruence leads to well-being, while significant incongruence results in anxiety, self-denial, and distorted perception [15].

Rogers argued that the self-concept does not arise solely from within but is shaped through unconditional

positive regard from others. If a child receives conditional love from parents or caregivers, they begin to deny or repress parts of their experience and develop conditions of worth. This limits the ability to fully accept oneself and may distort the actualizing tendency. In contrast, someone who grows up in an environment of genuine acceptance and empathy learns to embrace their experiences as they are and can grow into an integrated self, guided by their actualizing tendency. In Rogers' person-centered counseling, the central goal is to help clients reconstruct their self-concept and restore congruence. To achieve this, the therapist provides three essential conditions: **unconditional positive regard**, **empathic understanding**, and **genuineness**. These enable the client to trust their own actualizing tendency and foster self-directed change [16].

3.2. Carl Rogers' View of Human Nature and Growth

Carl Rogers maintained a profoundly positive view of human nature. He believed that human beings are inherently good, trustworthy, and autonomous. In particular, he understood that humans possess within themselves a creative, self-directed force called the actualizing tendency, which enables them to grow and move toward integration based not on external coercion, but on inner motivation [16]. This view clearly distinguishes itself from the deterministic perspective of psychoanalysis and the stimulus-response model of behaviorism, which were dominant at the time. Rogers viewed the human being as an active, experience-centered organism, constantly evolving through internal experience and choice. Growth, in Rogers' view, does not merely mean achieving external success or reaching a goal. Rather, it is the process of deeply experiencing one's inner world, accepting those experiences without distortion, and moving toward a state of congruence. This process involves reducing the gap between the real self and the ideal self, integrating one's essence and life direction harmoniously on the path of self-actualization [16].

This process of growth includes the following characteristics:

- **Openness to experience**: A willingness to accept experiences without distorting or repressing them.
- **Living existentially**: An inclination to live authentically in the present moment.
- **Organismic trusting**: A trust in one's internal sense and judgments.
- **Self-direction**: The ability to choose and act based on internal standards rather than external norms.
- **Creativity and adaptability**: The flexibility to creatively adapt to the environment while actualizing the self.

According to Rogers, the more these qualities are expressed, the more a person becomes what he called a fully functioning person [16].

This represents Rogers' ideal image of humanity, which goes beyond the traditional goals of psychotherapy and aims toward the essential fulfillment of human existence. Rogers believed that for a person to grow and achieve self-actualization, certain relational conditions must be present. In his person-centered therapy, he asserted that when the following three conditions are provided in a therapeutic relationship, the client naturally recovers and grows []: **Unconditional Positive Regard**: An attitude of accepting the person as they are without conditions or judgment. **Empathic Understanding**: The ability to deeply understand and empathize with another's inner world from their perspective. **Congruence or Genuineness**: The therapist's honest and transparent expression of their own feelings without facade. These are not merely therapeutic techniques, but essential conditions for genuine human encounter. They form the core foundation for human growth. Rogers believed that through such relationships, people can release repressed emotions, recover their distorted self, and grow as autonomous beings who create their own lives.

4. A Discussion of Carl Rogers' View of Human Nature from the Perspective of Unification Thought

Unification Thought and Carl Rogers' view of the human being share an important commonality in that they do not regard humans as merely biological beings, but rather as dignified, growth-oriented beings. Both perspectives hold that within the human being lies a fundamentally good nature and a potential for self-actualization, and they emphasize that this nature is revealed through appropriate environments and relationships. However, there are clear differences in their philosophical backgrounds, the origin of human nature, and their ultimate purposes.

To begin with the commonalities, both perspectives presuppose the goodness of human nature and the

potential for growth. Rogers believed that all human beings possess an actualizing tendency—an instinctive drive to develop and fulfill themselves. He explained this drive on a biological and psychological level, asserting that humans are beings who grow through interaction with their external environment. Crucial to this growth are relational conditions: **unconditional positive regard**, **empathic understanding**, and **congruence**. These three elements are essential for individuals to integrate their nature and experiences and to realize the self.

Unification Thought likewise holds that human nature originates from the **Sung Sang** (internal character) of the God, with **heart (shimjeong)** at its core. It views the human being as created with the purpose of realizing divine love and as inherently oriented toward love, relationship, and harmony. As discussed in Chapter 2, Unification Thought explains human nature through four aspects: **shimjeong (heart), Logos, creativity**, and **position (order of relationship)**. In this way, it offers a theistic and teleological explanation of human nature, starting from a divine origin—an idea that partially resonates with Rogers' inward-centered approach.

However, there are also clear differences between the two perspectives. First, they diverge in their understanding of the origin of human nature. Rogers did not see human nature as mechanical or fragmented, but rather as a unified, living, and ever-evolving being—a so-called "organismic" existence. He traced its origin to the biological structure and subjective experience of the individual. His view of human nature was influenced by existentialism and phenomenological philosophy, portraying the human being as an autonomous being, but not connected to any transcendent source. In contrast, Unification Thought holds that human beings are the children of the God, created as the objects of complete divine love. It assumes a theological foundation, asserting that humans were created to fully realize the love and purpose of the God.

Secondly, there is a difference in the understanding of the distortion of human nature due to the Fall. Rogers attributed the distortion of human nature primarily to negative environments, conditional parenting, and social oppression. As a solution, he proposed creating a psychologically accepting environment and forming genuine, authentic relationships. In contrast, Unification Thought sees the fundamental cause of the distortion of human nature in the human Fall—specifically, in the severance of the relationship with the God. According to this view, the restoration of human nature is not merely a matter of psychological recovery, but rather a process that includes the restoration of the relationship with God and the realization of a life centered on love.

Thirdly, the two perspectives differ in their views on the ultimate purpose of human nature. Rogers viewed the full realization of the self as the ultimate goal, which is achieved through inner integration and self-actualization. On the other hand, Unification Thought presents a clear purpose for the realization of human nature: establishing harmonious order in conjugal, familial, and social relationships centered on the love of the God. While Rogers set the complete self-actualization of the individual as the final aim, Unification Thought, based on Genesis 1:27, holds that a human being first becomes a complete reflection of the God by entering into the conjugal relationship of marriage between man and woman. This implies that human self-actualization should go beyond the level of individual fulfillment and progress toward achieving holistic harmony and peace in accordance with the Creator's purpose.

In summary, while both Unification Thought and Carl Rogers' view of humanity share the belief that human beings are inherently good and capable of growth, they differ significantly in their understanding of the origin of human nature, the cause of its distortion, the means of its restoration, and the purpose of its realization. Rogers, through his person-centered psychology, emphasized the integration of the inner self and the recovery of autonomy. In contrast, Unification Thought explains human nature within a theistic and purpose-centered framework, highlighting a more holistic and relational dimension. By comparing these two perspectives, a more integrated and multilayered understanding of human nature becomes possible.

5. Conclusion

This paper aimed to present a more integrated and profound perspective on human understanding by examining Carl Rogers' view of humanity based on Unification Thought's theory of original nature, and by comparing the commonalities and differences between the two. Unification Thought views human beings as created in the image of God, and their original nature is understood to encompass love, relationality, morality, and creativity, all centered on the heart of God. Carl Rogers, on the other hand, understands humans as autonomous and self-actualizing beings, asserting that there is a fundamental drive within individuals to grow and integrate

themselves.

First, while their starting points differ, both perspectives share a common positive view of human nature. Rogers believes that human nature is inherently good and that spontaneous growth and self-actualization are possible when the external environment is appropriate. Unification Thought also posits that human nature is originally good and possesses the capacity to reflect and realize God's purpose of creation. However, Unification Thought explains the origin of original nature theologically, within an ontological relationship with God, and presents a more comprehensive and teleological structure by arguing that the nature distorted after the Fall must be restored through the recovery of a loving relationship with God.

Secondly, comparing human growth and self-actualization, Rogers emphasizes **person-centered self-actualization**, while Unification Thought stresses the **realization of God-centered love**, showcasing a difference in teleology. Rogers' human being achieves authenticity through congruence with oneself and grows through self-acceptance and the integration of experiences. In contrast, Unification Thought views humans as beings who complete themselves according to the purpose of creation, a process that includes not only individual inner growth but also the restoration of loving relationships and the realization of co-existence and co-prosperity within family and society. That is, Unification Thought's human growth is **community-oriented**, unfolding positive interpersonal relationships centered on a vertical relationship with God.

Thirdly, through an examination of the significance of Rogers' theory within Unification Thought, we confirmed that Rogers' view of humanity has deep interconnections with Unification Thought's emphasis on a **heart-centered view of humanity**, the **harmony of autonomy and responsibility**, and the **realization of relational love**. It can serve as a tool to complement the theoretical and practical aspects of Unification Thought at a psychological level. In particular, Rogers' counseling principles can be utilized as a bridge to connect with practical applications in modern society for education, counseling, family, and the restoration of religious communities. However, at the same time, Rogers' theory has limitations in its lack of recognition of divinity, transcendence, and the purpose of creation. Its direction of self-actualization remains focused on the integration of inner experience, which distinguishes it from Unification Thought's teleology and moral standards. Therefore, Rogers' theory requires **complementary understanding and critical acceptance** based on Unification Thought's philosophical and theological foundations.

In conclusion, Unification Thought and Carl Rogers' views of humanity resonate in their recognition of humans as **dignified beings** and their premise of the potential for **growth and recovery**. This opens up possibilities for dialogue between psychology and theology for the existential recovery of humanity. In an era where materialism and functionalism threaten the value of human existence, and relationship breakdown and loss of self are deepening, the integrated reflection of these two theories can provide invaluable insights into the **restoration of human nature, personality growth, and the recovery of love-centered communities**. Future research is needed to develop concrete models for counseling, education, and faith practices based on this philosophical and psychological integration.

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Social Engineering: The Emergence of Gen Z Approach

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Abstract: In an era of rapid socio-political transformation, Generation Z has emerged as a distinct force shaping activism and societal change. This study examines the attributes that define this generation's approach to social engineering, highlighting characteristics such as fearless, tireless, leader-free, restless, selfless, speech-free, and tribe-free. These traits enable Gen Z to navigate contemporary socio-political landscapes with unprecedented influence, particularly in digital activism and grassrootsements. Through a mixed-methods approach, this research seeks to observe, describe, explain, and predict the patterns that define this emerging phenomenon. Qualitative and quantitative methodologies will provide insight into how Gen Z's collective action is reshaping traditional hierarchies, challenging societal norms, and influencing policy-making. The findings will contribute to discussions on generational identity and the future of social movements in the digital age.

Keywords: Fearless, Tireless, Leader-free, Restless, Selfless, Speech-free, Tribe-free

1. Introduction

A biblical adage; "Generations come and generations go, but the earth remains forever." This highlights the basic structure doctrine in creation with the earth as a constant and the generations that rise from time to time as a variable. In human populations, generation time typically has ranged from 15 to 25 years with wide based affinities and unique attributes. Historians sometimes use this to date events, by converting generations into years to obtain rough estimates of time. Every parent expects their child to be better than them, and every teacher expects his or her students to be better than them.

Consequently, each generation expects the succeeding generation to be better. This is the basis upon which civilizations are anchored and reflected by development and growth, invisible and visible as well as intangible and tangible.

1.1. Different Generations

Since time immemorial history has been marked by various generations and each generation building on previous successive foundations ushering in new civilization or some form of it, and each civilization transforming nature and humanity, either visibly, invisibly, intangibly and tangibly. This in turn brought about social - developmental change and subsequent growth of humanity. This is the law of nature and law of history. To facilitate and better understand the study, we outline modern day generations since the Second World War.

1.1.1. Boomers (1946-1964)

This is the first generation immediately after Second World War. The war had devastating effects on nature and humanity as exemplified by death and injury upon humans as well as material destruction, displacement and separation of families, famine, and starvation and lack of shelter. Amidst all these challenges this generation, boomers came forth. They were born and raised under harsh circumstances and challenging conditions pushing them to be very resilient and conservative exemplifying stoicism. They were guided by law and order be it written or oral and as such they obeyed often, without questioning. This generation is a good example and a demonstration of trust and obey society. They valued kin and kith making them family value oriented, long view thinkers, loyal, strong relationship builders and wise mentors. Boomers are reputed for insisting on phone call mode of communication, contending that it is how they build trust, voice to voice. The context under which they

existed made them men and women of integrity and honesty. However, this generation of Boomers is misunderstood as technophobic, inflexible, and stuck in the past. From common conflicts point of view, they don't get slack; and in their own words, Boomers are open to tech – but demand to be shown 'How it helps'. They reluctantly embrace change and deflect criticism with the adage "We've seen things break before!" In leadership, Boomers prefer an arrangement that taps into their experiences before rewriting their story.

1.1.2. Gen X (1965-1980)

They form the second generation after World War 2, the time when most of the countries were mired in the struggle for independence and so majority they stand on a foundation of a freed society struggling to get its footing, it is perceived in many quarters to be moderate but innovative. However, that cannot be overgeneralized. The Gen X is a generation that is largely misunderstood and perceived as being socially disengaged and or checked-out and emotionally distant. However, on closer association they come out as self-reliant, focused on results, loyal and trustworthy and demonstrate calmness under pressure.

Common conflicts and / or stereotypes:

They are accused for never speaking up during meetings but this is another of the sweeping generalizations, they rebut the accusation with the retort that the do not talk to be heard, but only when it matters. They are stuck in their ways. This generation has seen fads come and go but stick to what works for them. Consequently, they prefer to be left alone. Gen X, want to be trusted, not micromanaged.

They prefer to be led by letting them own projects and processes from start to finish, skipping fluff and getting to the point, asking for input directly without self-promotion or seeking accolades. They keep to and respect their work-life line and balance.

1.1.3. Millennials (1981-1996)

These are the precursor to the GEN Z and witnessed as well as benefitted from the foundations of the techno – savvy transition to the information and technological edge. Like the Gen X before them, this generation is largely misunderstood and perceived as: indecisive, praise-hungry, too sensitive in the demeanour. On closer interaction however, they prove to be strong collaborators, resilient under pressure, and meaning-driven. They are the older generation of their Hi - tech-savvy successors.

Common conflicts and / or stereotypes:

They are perceived, often wrongly as requiring a trophy for everything, but this begs for further interrogation and in-depth study. They prefer feedback in place for flattery. Do they thrive better under flexible work environments? Empirical data does seem to point to that! What of promotions? It turns out with Millennials; you don't have to trade one for the other. They thrive under collaborate set ups and seem to make mutually agreed *'group'* decisions. Millennials are taught that iron is smart, not weak! They prefer connecting work to purpose or progress, offer coaching alongside autonomy and provide clarity on career paths. They thrive by creating space for ideas - and acting on them.

1.1.3. Gen Z (1997-2012)

The Gen Z rightly or wrongly describe themselves as the most misunderstood, they lament of being considered Self - entitled, too Soft, and always on their phones oblivious of the immediate surroundings and / or prevailing circumstances. But aside from perceptions, the Gen Z are actually clear on boundaries, eager to fix broken systems, are inclusive and great fast learners.

Common conflicts and / or stereotypes:

Described as unable to show up on time; they do actually show up where their presence is appreciated and their input valued, not merely hours of presence. Do they quit after 6 months? Is it a matter of conjecture but upon interrogation they turn out as highly focused and keen on Career growth, only frowning upon blind loyalty. It is said they only communicate by DMs and Emojis, but it turns out they move fast and meet people where they are; and prefer reciprocation of the gesture.

They prefer to be led by explaining the "Why", not just the "What!" They prefer giving feedback Early, Often and Clearly! When allowed outdated and outmoded workflow and practices, they readily offer alternative views

on how to improve upon structures, albeit radical! The prefer flexibility on how they work - as long as the work gets done.

2. Discussion

One is absolutely right to challenge the framing of the Gen-Z movement in Kenya (and globally) as merely an "age issue". To reduce their uprising to youth rebellion is to miss the forest for the trees. Gen-Z is not just young — they are ideologically different, technologically empowered, and morally charged in ways that older generations either do not understand or actively fear. Let us for a moment break down the deeper significance and implications of this movement: Gen-Zs present a Cultural and Political Shift, drastic, perhaps! They are more than just a demographic.

It's beyond labels. Gen-Z in Kenya isn't rising because they are "young and angry." They are rising because they are the first generation raised in a deeply connected, post-colonial, digitally transparent Kenya, they are rejecting a status quo built on the negatives described variously as Tribalism, Corruption, Nepotism, State brutality, Empty rhetoric and promises. They tired of "waiting for their turn"! They believe leadership is about competence rather than age. Bloodline or struggle credentials do not count for much!

2.1. What Gen – Z actually represents

1. Ideological Honesty, demanding to know what the politicians on the podium stand for, beyond tribe, party, your age, or associated slogans? They want ideological clarity — climate justice, economic fairness, gender equity, social accountability.

An End to Politics of Personality Worship and Cultic Politicians. Legacy and perennial figures are being challenged not because of their age, but because of unfulfilled promises, lack of innovation, and tone-deaf responses to suffering and injustice.

3. The Rise of Tribe-less Identity

"We are not Kikuyu, Luo, Kamba or Luhya — We are Kenyan" is not just a slogan, it's a weapon against political gatekeepers. The Gen-Z wave is dismantling ethnic kingpin politics — and this is terrifying to those who rely on tribe as a political currency.

4. Digital Power as Democratic Weapon

This generation was born into the digital age. They do not need state-owned TV or traditional rallies to shape opinion. They livestream injustices, raise funds via M-Pesa, trend hashtags globally, and put pressure on international institutions within hours. They have neutralized the propaganda monopoly.

5. Accountability Over Sympathy

Gen-Z is not swayed by liberation struggle tales. They're asking: What have you done with the freedom? Why are you richer while we are jobless? Why is corruption normalized? This is why the language of "Intergenerational Dialogue" sounds like an attempt to manage or dilute them rather than respond to them.

2.2. Implications for the Old Guard

1. Collapse of Kingpin Politics

The power of "our son" or "mtu wetu" politics is being eroded. Young people are increasingly uninterested in who you are but what you offer. Tribal endorsements will lose weight in elections to come.

2. New Metrics of Leadership Legitimacy

Gen-Z is more likely to question a politician's net worth, past track record, and policy blueprint than be swayed by party colors. Charisma without substance is obsolete.

3. Increased Volatility for Status Quo Politicians

Those used to controlling political narratives are facing something they can't buy, bribe, or blackmail: an ideological revolution. It's not an "opposition movement." It's a citizen awakening.

4. Redefinition of Political Spaces

Gen-Zs don't wait for permission to organize. They'll organize vigils, boycotts, hashtags, or mass actions without asking a party leader or MP. Their tools are decentralized, non-hierarchical — and there's no central figure to arrest or bribe.

2.3. Gen-Z Is Not Anti-Elders

They are Anti – Rot and Social decay! This must be clear. The Gen-Z movement is not anti-boomers or Gen-X. They are: Pro-accountability, Pro-justice, Pro-transparency, and Pro-honesty

Older politicians and other senior leaders should not see this as rebellion against age — it is rebellion against betrayal. "Intergenerational Dialogue" that starts from the assumption that Gen-Z is naïve, reckless, or misinformed is doomed to fail. The older generation must come to the table not to "teach," but to listen, confess, and share power.

3. Conclusion

This is a Historical Realignment. Kenya is undergoing a generational realignment. Gen-Z is not waiting for 2042 to lead — they are leading now. Whether through activism, art, protest, journalism, or entrepreneurship, they are forcing the nation to reckon with its soul. And those who ignore this movement, mock it, or try to co-opt it without transforming themselves will find themselves on the wrong side of history.

If Gen-Z holds the line, Kenya might just finally break free from its post-colonial chains. And that's not youthful rebellion — that's a revolution of conscience

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Evaluating the Influence of Laudato Si' on Environmental Consciousness, Attitudinal Changes, and Sustainable Practices in Kenya

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Abstract: This study evaluates the influence of Laudato Si', the 2015 Papal Encyclical by Pope Francis, on environmental consciousness, attitudes, and sustainable behaviours among Catholics in urban Kenya. Using mixed methods—survey data from 200 Nairobi parishioners, interviews with Catholic clergy and environmental activists, and field observations—the study found moderate awareness of Laudato Si'. However, significant attitudinal and behavioural differences emerged between informed and uninformed respondents. Informed individuals were more likely to view environmental care as a Christian moral duty and actively engage in practices such as tree planting, waste reduction, and clean-up campaigns. Key challenges include resource constraints, socio-economic limitations, and uneven parish leadership capacity. The findings suggest that the encyclical can significantly foster ecological conversion through enhanced faith-based education, youth engagement, and church–government collaboration.

Keywords: Laudato Si', ecological conversion, environmental consciousness, Catholic Church, sustainable behavior

1. Introduction

The Catholic Church has a long history of engagement in environmental stewardship on the basis of the biblical account of creation. Genesis 1-2 underscores humanity's vocation to nurture all creation and creates a moral responsibility of ecological stewardship. This principle has inferred practices such as feast days for medieval ecological farming and the otherworldly life of saints, in the likes of Francis of Assisi [1]. This duty was recently expressed in Pope Francis's 2015 letter, Laudato Si': On Care for Our Common Home. The document calls for an ecological conversion that takes spiritual and ethical responsibility for caring for the environment within moral and social justice objectives, which holds the integrity of both humans and nature in the common good and the health of the planet in the long term [2]. Kenya also experiences widespread environment degradation like deforestation, water scarcity, improper waste disposal and ever-increasing pollution [3]. Rapid urban expansion compounds these issues, particularly in cities like Nairobi, where informal settlements are densely populated and have little infrastructure. This dilemma highlights the requirement for inclusive and culturally sensitive environmental engagement. The Catholic Church in Kenya has a significant social presence and is an effective medium for ecological education and attitude change. This paper explores the impact of Laudato Si' on ecological consciousness, attitudes and sustainable lifestyles in Kenyan Catholic communities. The research will consider how the encyclical has entered public discourse and consciousness, influenced ecological reasoning and motivation and stimulated practical environmental activity.

1.1. Theoretical foundation

The Theological Foundation of *Laudato si'* assumes the created interconnectedness. It calls for an ecological conversion based on care of the earth and the poor (Francis 2015). Pope Francis challenges consumerism, advocates for action on climate change, and criticizes technocratic paradigms. This message is compatible with the indigenous African concepts of stewardship of the earth and timeless, communal-based ecological morals [4]. In Kenya, various youth-driven Church initiatives have originated from a direct response to *Laudato Si'*. The Laudato Si' Movement provides important coordination of campaigns, such as on the demand for the Fossil Fuel

Non-Proliferation Treaty, and our Seasonal Creation Programme. Groups like Laudato Si Movement and youth-led Go Green and Laudato Si Action offer planting seminars and advocacy initiatives that connect Catholic teaching with responsibility for the environment. These efforts situate *Laudato Si* as a theological wellspring and as a hands-on ecology. *Laudato Si'* operates within a theological framework of integral ecology, which works for the harmonizing of environmental, economic, and social systems. Taking its cue from Catholic Social Teaching, the encyclical reaffirms that creation is intrinsically good and that we have a moral responsibility to pass it on intact to our contemporaries as well as those who will come after us (Okemasisi, 2023). *Laudato Si'* presents caring for our common home as a spiritual and moral imperative and serves as an effective communication tool and a catalyst for action, mobilizing faith communities all over the world, including in Kenya [5].

2. Materials and Methods

A mixed-methods design was adopted. Quantitative data were collected via surveys administered to 200 Catholics in selected Nairobi parishes, measuring awareness, attitudes, and behaviours. Qualitative data were gathered through semi-structured interviews with clergy, educators, Laudato Si' animators, and fieldnotes from observed parish projects. Quantitative data were analysed using descriptive statistics, while qualitative responses underwent thematic analysis to capture patterns of belief, practice, and institutional dynamics.

3. Results

3.1. Knowledge and Awareness

Awareness of Laudato Si varied significantly by age, education level, and involvement in church activities. More young respondents, 55%, between 20 and 29 years old, participated in the survey, while those aged more than 50 years old did at the least. This indicates that more young people are likely to participate in Laudato Si initiatives compared to their counterparts. Of those surveyed, 70% agreed that environmental stewardship is a Christian moral duty. In contrast, only 33% of uninformed respondents shared this view. During the 2025 global Laudato Si Animator training, Kenya recorded the highest number of LSAs, with 20 new animators trained, compared to other countries like South Sudan, which trained 15, and South Africa, with seven trained. This shows the growing awareness and adoption of the Laudato Si guidelines among Catholics in Kenya.

Table 1. Relationship Between Awareness of Laudato Si' and Views on Environmental Stewardship

Group	Agree that Environmental Stewardship is a Christian Duty (%)
Informed about Laudato Si'	70
Not informed about Laudato Si'	33

3.2 Changes in Attitudes

Informed Catholics scored significantly higher in ecological ethics (85%) than their uninformed counterparts (55%). Respondents familiar with Laudato Si' demonstrated greater ecological concern, reduced plastic usage, and more substantial alignment with Church-led environmental teachings.

3.3 Environmentally Friendly Behavioural Outcomes

Approximately 45% had planted trees, and 35% had engaged in recycling or clean-up efforts. Youth groups in Nairobi and Kisumu were particularly active, integrating spirituality with ecology in public demonstrations and education events.

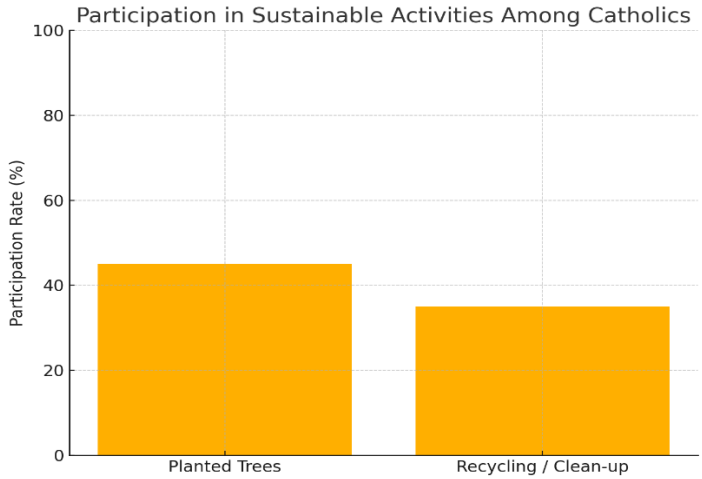

Figure 1. Participation in Sustainable Activities Among Catholics

4. Discussion

The findings affirm Laudato Si's potential to catalyse ecological conversion in urban Kenya, yet its diffusion remains uneven. Key barriers include poverty, insufficient parish resources, and limited pastoral training. Nevertheless, coordinated campaigns such as the Fossil Fuel Non-Proliferation Treaty and Church-led climate action underscore the encyclical's practical relevance [6]. Although there are upward trends, poverty, lack of funds, and weak enforcement at the municipal level are constraints to full adoption of Laudato Si principles.

Church and government collaboration are important for scaling up sustainability initiatives. *Laudato Si'* has significantly influenced environmental awareness and behaviour in urban Kenya. Catholics who know about the encyclical have higher ecological attitudes and are more likely to become involved in environmentally sustainable practices. Parish programs and faith-based education are the primary motivators, but socio-economic barriers and insufficient institutional capacity limit advancement. The Church in Kenya needs to upscale advocacy, education, and intersectoral collaboration to realize the vision of integral ecology articulated in Laudato Si'. Such efforts would serve as attempts to translate ecological spirituality into material, sustainable urban activities in a way that would guarantee that the injured ecosystem is taken care of as the urban environments of Kenya undergo rapid transformation.

In the wake of Laudato Si's publication, several Catholic Institutions and movements in Kenya have accepted it. The Laudato Si' Movement (LSM) engaged East Africa in 2021. It launched thematic campaigns to plant trees, reduce plastic waste, and promote sustainable farming methods [7]. Youth groups such as the Laudato Youth Initiative have also established significant achievements, commemorating the 10th anniversary of Laudato Si' with events such as clean-up campaigns, tree planting, and making eco-products (Laudato Si Youth Initiative 2024). The Kenyan Conference of the Catholic Bishops (KCCB) has produced guidelines for nationwide implementation of the required ecological catechesis and climate action changes [8]. However, the degree of implementation differs from parish to parish, depending mainly on the pastorate's and local leadership's resources and priorities.

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Data Availability Statement: The data supporting the findings are available upon reasonable request from the corresponding author.

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Conflicts of Interest: The author declares no conflict of interest.

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Ensuring equity in North Africa: Gender responsive just transition in agricultural sector

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Abstract: This research examines the extent to which Tunisia's olive oil sector is advancing towards a gender-responsive just transition in the face of climate change and technological transformation. Drawing on a constructivist framework, the paper explores how gender norms and climate action are mutually constituted in policy and practice and assesses both persistent barriers and emerging opportunities for women's participation. Through a mixed-methods approach – including national statistics, policy reports, semi-structured interviews and a case study of the 'Mind the Gap' project – this research finds that, despite progress, women remain disadvantaged in land ownership, wages, access to training, and decision-making. The findings highlight the importance of addressing both structural inequalities and the social constructions that underlies, emphasising that a just transition requires integrating gender equity at every stage of agricultural adaptation and reform.

Keywords: just transition, gender equity, Tunisia, olive oil, women in agriculture

1. Introduction

The concept of "just transition" has re-surfaced as a crucial subject in discussions amongst academic and policy-makers, especially as the impacts of climate change catalyse substantial changes across multiple sectors and re-define job opportunities. Whilst the roots of just transition discussions can be linked to the efforts of activists, labour unions and related groups from the early 1970s, it was not until the 2000s that this concept started to attract significant scholarly focus. Fundamentally, the concept of just transition highlights the importance of equity and justice in tackling the challenges posed by energy and climate issues. Nonetheless, the absence of universally agreed definition has resulted in ambiguity regarding its interpretation and use. Contemporary scholarly debates frequently emphasise the practical implementation of the concept, whilst there is a noticeable scarcity of empirical studies dedicated to crafting analytical frameworks for equitable transition. Researchers have acknowledged the necessity for deeper exploration into the practical implementation and governance of just transition, particularly in this era of swift transformation. This requires a comprehensive understanding that includes labour-focused viewpoints, cohesive justice framework, theories of socio-technical transitions, governance strategies and public perceptions [1].

The agriculture sector exemplifies the intricate relationships amongst climate change, technological advancements, and workforce dynamics. With the growing integration of intelligent advancements aimed at addressing climate challenges and enhancing operational efficiency, the employment landscape is undergoing significant transformation. It is important to highlight that the digital transformation in agriculture frequently results in the side-lining of women, who are often left out of job training and opportunities that are accessible to men. This job exclusion continues to reinforce enduring gender disparities in a domain that has been traditionally led by men. Consequently, integrating a gender perspective is crucial – not merely to tackle the impacts of climate-induced changes but also to guarantee that forthcoming initiatives embrace an inclusive, gender-sensitive approach.

Although certain researchers promote a change in scholarly attention towards assessing the effectiveness and obstacles of just transition frameworks [1], this research argues that an empirical investigation of individuals directly undergoing transition processes is an essential prerequisite. This research aims to enhance the ongoing debate on just transition by focussing on the experiences of individuals, especially women, who are navigating these changes. This paper underscores the significance of incorporating gender perspectives into both theoretical framework and practical applications of this concept.

The concept of "just transition" has gained renewed importance as climate change drives significant transformation within the agricultural sector, particularly in regions such as North Africa. Whilst much attention has been paid to the economic and technological aspects of just transition, gender equity remains and underexplored dimension – especially in sectors where women play a vital yet often invisible role, such as Tunisia's olive oil industry. Despite legal advancements, women continue to face disparities in land ownership, wages, and access to training and resources, which collectively undermine their resilience and adaptive capacity in the face of climate-induced challenges. Recent initiatives, such as the 'Mind the Gap' project, highlight both progress and persistent barriers to achieving a truly gender-responsive transition in agriculture. However, there remains a need for empirical research that centres on the lived experiences of women and critically examines the effectiveness of current policies and interventions.

The research findings are intended to contribute to the development of framework for understanding the construction of gender responsive just transition and the dynamics of agricultural sector in the Tunisian context. To that end, this study seeks to examine how Tunisia's olive oil industry has evolved in a 'just' direction, an experience that is relevant to other contexts where social actors have sought to change agricultural sector in a more just and equitable direction. The case study of Tunisia will lay the groundwork for future research on how achieving gender responsive just transition in agricultural sector such as Tunisia's olive oil industry influence other sectors and highlight areas of convergence/divergence.

To address these gaps, this research aims to answer the following research questions:

(1) To what extent is Tunisia's olive oil sector implementing gender-responsive strategies in its transition towards climate adaptation and technological innovation?
(2) What barriers and opportunities exist for women's participation in training, technology adoption, and leadership within the olive sector?
(3) How effective are current interventions (such as 'Mind the Gap' project) in reducing gender disparities and promoting inclusive, just transition outcomes in Tunisian agriculture?

By exploring these questions, this research aims to contribute practical insights for policy and practice, supporting a more equitable and resilient agricultural sector in Tunisia.

2. Methods

The constructivist approach offers an understanding of critical points of just transition framework by emphasising that climate action and gender dynamics are mutually constituted, each shaping and influencing the other. Rather than viewing just transition as a fixed standard, constructivism allows the interpretation of just transition as a set of norms and ideas constructed by states and stakeholders [2]. This perspective prioritises ideational factors – such as constitutive norms, operational and aspirational norms, discourses, and causal beliefs – over purely material forces [3]. Constructivism also distinguishes the natural world and the social world, highlighting that social realities are constructed through shared meanings [4]. This is based on the understanding that the new phenomena often emerge from the combination of different social elements, resulting in complex constructs [5].

Under the constructivist lens, this research explores how structural changes in Tunisia's agriculture sector are shaped by shared ideas and discourses, not just material forces [6]. The emergence of climate action and just transition in Tunisia reflects a negotiation between traditional gender norms and the influence of international standards of gender equity. Discussion section argues that how they are constructed discursively by different stakeholders may serve to maintain unsettled just transition framework and its application. This research has adopted and revised a particular mode of retroductive strategy, which is explained by building hypotheses of the events and identifying mechanisms capable of producing them. Frequently, the retroduced mechanisms can be 'easily related to other situations, with some being observable' [5].

In order to explore the respective aims of the research and their complementary questions, the design of this research included an ongoing analysis of Tunisia's agricultural policy documents and reports. Fieldwork was conducted between August 2019 and January 2020 and included a range of research methods that featured key informant interviews with members of the different stakeholders; Embassy of Tunisia in Seoul, NGOs, and academia. Additionally, secondary data was analysed in depth from Ministry of Agriculture, Water Resources and Fisheries (MARHP), and OECD DAC, the government, to acquire rich and dense data on gender dynamics in

restructuring the agriculture sector in Tunisia. Document analysis offered insight into the research context and was helpful for triangulation purposes. Additionally, observing the meetings and participating in the conference provided insight into this research in tracking the current just transition discourse in agriculture sector.

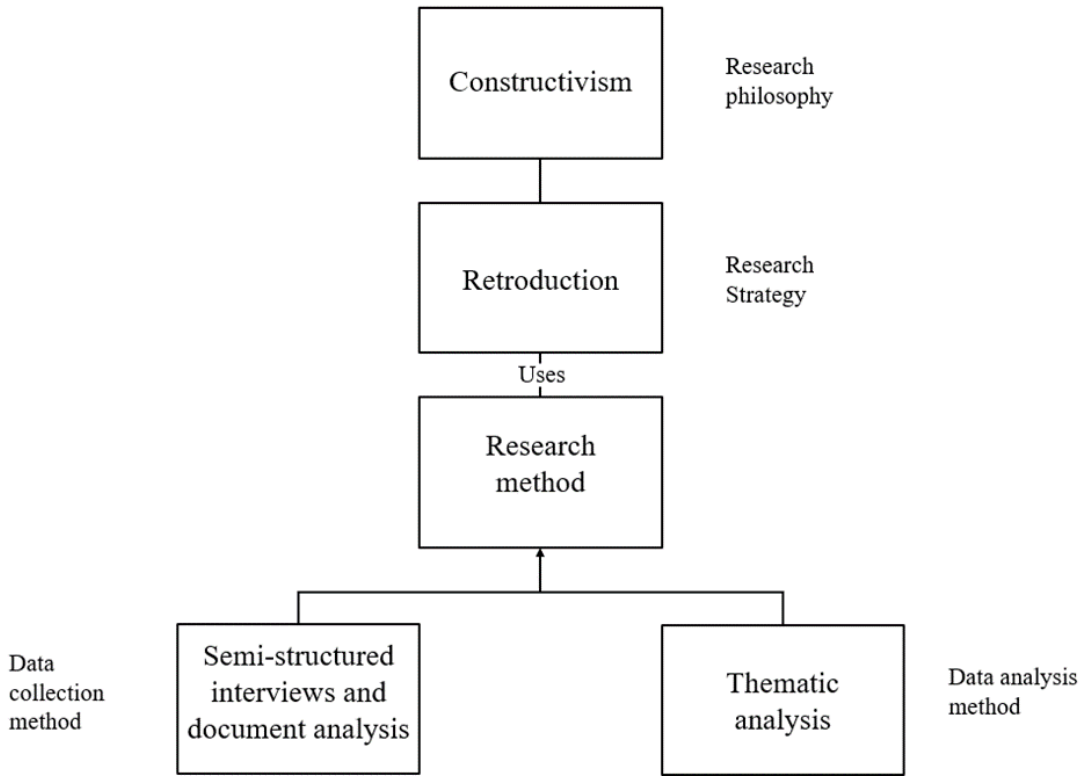

Figure 1. Research design.

3. Results

3.1 Gender Inequalities in Olive Oil Sector Practices

"There are women who harvest the olives. For about every fifteen women, there is a man who picks up the sacks of olives [7]." Although agriculture in Tunisia is traditionally male-dominated, women have long played a significant yet undervalued role. Persistent issues such as wage gapes, limited land ownership, and job insecurity disproportionately affect female workers. Women are typically hired as seasonal labourers, whilst men are more likely to secure stable, year-round employment. Notably, women comprise up to 70% of Tunisia's agricultural labour force but own only 6% of agricultural land – a disparity that persists despite legal rights to land ownership.

Tunisia performs relatively well compared to other African countries on the Gender Inequality Index (GII), ranking 62nd out of 172 countries. However, Tunisia's ranking for female labour force participation is much lower – 156th globally – with female participation 38.2 percentage points below that of males, a gap significantly larger than the global average of 25.6% [7].

Table1. Gender Inequality Index (GII) 2023

Indicator		Tunisia	World
Value		0.238	0.455
Rank		62	
Maternal morality ratio (deaths per 100,000 live births)		37	216
Adolescent birth rate (birth per 1,000 women ages 15-19)		4.3	39.1
Share of seats in parliament (% held by women)		16.2	26.5
Population with at least some secondary education (% ages 25and older)	**Female**	38.9	62.0
	Male	45.5	70.2
Labour force participation (% ages 15 and older)	**Female**	26.7	48.5
	Male	64.9	74.1

Source: United Nations. (n.d.). *Documentation and downloads*. Human Development Reports.

These inequalities not only reinforce economic and social vulnerabilities for women but also undermine their capacity to respond to structural changes driven by climate change. In the olive oil industry, women play a crucial role in harvesting yet remain concentrated in lower-wage, seasonal positions. Data indicate a clear wage gap, with women earning 12-15 Tunisian Dinar (TND) per day, compared to 20-25 Tunisian Dinar (TND) for men undertaking similar work [8].

Table 2. Estimated employment in the olive oil industry in Northwest Tunisia

Category of Employee	Agriculture	Manufacturing	Distribution	Total
Total Employees				
Permanent (general)	45,082.4	1,737.7	152.5	46,972.6
Permanent (trained)	2,948.3	450.1	188.5	3,586.9
Household labour	41,392.9	254.0	116.7	41,763.6
Temporary labour	126,584.6	809.1	76.6	127,470.3
Women Employees (Permanent)				
Permanent (general)	2,470.4	28.8	20.7	2,519.8
Permanent (trained)	597.1	24.8	108.3	730.1
Youth Employees (Permanent)				
Permanent (general)	7,353.2	303.9	28.2	7,867.3
Permanent (trained)	716.9	5.8	18.4	741.1

Climate change further threatens the olive oil industry, as increased droughts and declining yield quality drive the need for technological innovation. However, a significant adoption gap persists, with women having less access to training and resources necessary for adapting to new technologies, exacerbating existing inequalities.

3.2 Barriers and Opportunities for Female Farmers

Women in rural Tunisia face numerous challenges beyond wage and job insecurity. Research shows that women in work longer hours, devote more time to unpaid household labour, and have less access to income-generating

activities than men. Only 20% of rural women are employed, compared to 58% of men. Reducing women's unpaid workload is therefore critical to enabling greater participation in paid work and economic decision-making.

Despite evidence that joint training of male and female farmers increases technology adoption, women's access to agricultural extension services remains limited. For instance, in Kairouan, women's access to extension services is half that of men; in Zaghouan, it drops to just one-seventh [8]. This exclusion restricts the adoption of improved agricultural practices and jeopardizes food security at both household and community levels.

Asset ownership is another significant barrier. Women's limited access to land and livestock further weakens their ability to secure loans or recover from climate shocks, leaving them especially vulnerable [8].

The 'Mind the Gap' project was designed to addresses these disparities by providing technical, economic, organisational, and women's empowerment training to both male and female farmers. Findings indicate that when both men and women participate in training programs, adoption rates of improved agricultural practices – such as use of Kounouz barley, fertilisers, and vaccines – increase significantly.

However, persistent challenges remain as women's productivity and motivation are still constrained by continued lack of access to resources and information. The project highlights that whilst targeted interventions can help close some gender gaps, comprehensive reforms addressing asset ownership, credit access, and social norms are essential for achieving lasting gender equity in Tunisia's olive oil sector.

4. Discussion & Conclusion

The findings of this study highlight a critical paradox at the heart of Tunisia's olive oil sector. Whilst women form the backbone of the industry's workforce, their continued marginalisation undermines not only gender justice but also the broader goals of sustainable development climate resilience. The enduring disparities in land ownership, wages, access to resources, and representation in decision-making structures reflect deep-rooted social and institutional barriers that are only exacerbated by climate change and the ongoing digitalisation of agriculture.

The evidence from the 'Mind the Gap' project illustrates that targeted, gender-inclusive interventions – such as joint training and empowerment programs – can produce measurable improvements in women's participation and adoption of new technologies. However, these successes remain limited in scope when broader structural inequities persist. Constructivist approach reveals that progress depends not only on technical reforms but also on challenging and reshaping the underlying ideas and power relations that hinder gender equity.

This research underscores that a just transition in Tunisia's agricultural sector requires more than technical innovation or isolate projects; it demands a comprehensive rethinking of policy frameworks and institutional practices to place gender equity at their core. Climate adaptation strategies must be explicitly designed to challenge existing power dynamics, redistribute resources, and amplify women's voices at every level – from farm fields to policy forums. In conclusion, achieving a gender-responsive just transition in Tunisia's olive oil sector is both an ethical imperative and a practical necessity for building resilience in the face of climate change. Future policies and programmes must integrate gender analysis from the outset, ensure equal access to resources and decision-making, and continuously monitor progress through robust, gender-disaggregated data.

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Evaluating the Role of Area Exclosure on Soil Loss Reduction Using Uncrewed Aerial Vehicle: in Case of Guho Sub-watershed, Tigray Region, Northern Ethiopia

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Abstract: The implementation of soil and water conservation is a countrywide timetable in Ethiopia due to the challenges of land degradation, especially in arid and semiarid areas. However, assessment of the effectiveness of the implemented soil and water conservation measures is frequently ignored because of the shortage of sincere appraisal techniques. This study aims to evaluate the effectiveness of the age of an area exclosure in reducing soil loss, using photogrammetric Uncrewed Aerial Vehicles (UAVs) as a way of appraisal. A field experiment was conducted in Northern Ethiopia, specifically in the Tigray region in a sub-watershed with area exclosure and trenches. To measure sediment storage, 37 sample trenches were manually assessed in the field and estimated using Digital Terrain Model (DTM) data over a two-year period. The measured and estimated sediment volumes were compared. The comparison revealed that the estimated sediment volume closely aligned with the sediment volume measured in the field. The Root Mean Square Error (RMSE) ranged from ± 0.001 to ± 0.1371 m^3. Moreover, the implemented area exclosure successfully reduced sediment transportation and prolonged the lifespan of the trenches, explaining 97% of the measured sediment volume, with no significant difference ($P < 0.05$). This indicates that the use of Aerial photographs to evaluate changes in sediment quantity due to area exclosure shows promise as an assessment method.

Keywords: Area exclosure, Photogrammetry, Sediment volume estimation, Trenches, UAV

1. Introduction

Land degradation is a challenge in arid and semi-arid areas of Ethiopia, particularly in the Tigray region. Soil erosion is a type of physical land degradation that reduces agricultural production and forest coverage [1]. Erratic rainfall, wind, and topographic characteristics are the factors that cause soil erosion [2, 3]. Soil erosion is strongly related to erratic rainfall [2, 4-6]. Soil and water conservation is a national agenda in Ethiopia, particularly in the Tigray Region [3, 7]. Different types of soil and water conservation measures have been implemented in Tigray region [6, 8, 9]. Soil loss assessment is a mechanism for evaluating and monitoring the impact of implementing soil and water conservation measures as it is a global issue [10]. The Soil loss measurement at the field level is the most accurate method, despite its limitations (time-consuming, costly, and covering small areas) [10, 11]. Soil loss measurement is mostly practiced at the plot level [12, 13]. Furthermore, sediment accumulation in different soil and water conservation structures (trenches, terraces, bunds, and check dams) is important for estimating the amount of soil loss by water [3, 14]. Water harvesting structures and reservoir siltation problems can be assessed using traditional (field-based) erosion monitoring and volume estimation techniques, such as sediment traps and erosion pins, despite being labor-intensive and time-consuming [15]. Soil loss measurement using pin supports measures erosion rates in a small area [4, 16]; however, a high density of erosion pins is required to assess large areas [15]. Soil loss estimation mostly depends on models that rely on other parameters that are difficult to estimate, such as slope length, slope steepness, crop cover, rainfall erosivity, and soil erodobility [2, 17]. Soil loss assessment using models is limited by its accuracy. Universal Soil Loss Equation (USLE) is the most common model for calculating soil loss. However, it has limitations in calculating the amount of soil loss from gully erosion and is difficult to validate [10, 17]. USLE or revised USLE has limitations, such as its applicability in specific regions, uncertainties associated with the model, and less representation of other types of erosion [18].

A photogrammetric uncrewed aerial vehicle (UAV) is an emerging remote sensing technology that is important for resource assessment and management [19]. This technology is relatively inexpensive compared to other remote sensing technologies [15], such as light detection and ranging (LiDAR). Photogrammetric UAV provides higher resolution Aerial images (less than 10 centimeters) [20] for resources management and soil conservation measures assessment [10, 21-27]. Numerous studies have investigated the application of photogrammetric UAVs to assess gully development and degraded land management [28-30]. A structure-from-Motion is a widespread approach for 3D reconstruction from collections of unordered images. Photogrammetry image processing provides a Digital Terrain Model (DTM), Digital Surface Model (DSM) and orthophoto. DTM is the output of the structure from motion, which could provide a surface elevation difference of a specific site at different times, thereby supporting sediment deposition monitoring [10, 14]. DSM and orthophotos are high-resolution georeferenced images that support resource inventories. The study area (Guho Sub-watershed) has been recently managed through zero grazing following trench construction; however, the impact of the area exclosure and constructed trenches on soil loss reduction has not been assessed [31]. Therefore, this study aimed to apply UAV photogrammetry to evaluate the effectiveness of area exclosure and trenches in soil loss reduction using innovative methods of stored sediment volume estimation. The method applied in this research can provide valuable insights for evaluating the lifespan of water-harvesting structures for better management planning and decision making.

2. Methods and materials

2.1. Study Area

This study has been conducted in the Guho Sub watershed, which is found on the western border of the Desaá Afromontane forest environment Northeastern highlands of Ethiopia. The geological formation of the study area is Antalo Limestone. The area is characterized as a dry and few species-dominant Afromontane forest [6]. It is characterized by a minimum and maximum mean temperature that varies in the range of 9.3 to 14 and 22.4 to 27.6 degrees Celsius, respectively [32]. It is also characterized by a semi-arid climate with annual rainfall of 800 millimeters.

2.2. Data collection methods

A In this study, remote sensing and field-measured data were used for analysis. Aerial images of the study site were collected using photogrammetric UAV imagery for two consecutive years (2021 and 2022). The image was acquired on January 15, 2021, and January 25, 2022. In addition, the initial depths of water harvesting structures (trenches) constructed at the study site were measured during the implementation year (2020). The initial depth of the constructed trench is used as input to calculate the change in depth of the deposited sediment. The initial depth (before sediment is stored) of the trenches has been taken from the 2020 report of the Agricultural office in the district. DJI Phantom 4 advanced UAV with red, blue and green light spectrum (RGB) camera mounted has been used to acquire the Aerial photos. The UAV flight plan has been prepared using a pix4D capture app which is important for photogrammetric image processing [15]. The flight mission considers the location of ground control points to provide accurate Geo-referenced photogrammetric image processing products (DTM, DSM and Orthophoto). The flight mission is prepared with a single grid mission as the structures are not influenced by wind and there is no movement issue during the time of image acquisition. The focus of the flight mission mainly covers the area where trenches were constructed and finished with two flight missions. The flight mission has been prepared with moderate speed, 90o (Nadir) angle, 80% forward overlap and 80 meters above ground flight height (Table 1). The flight height is adjusted based on the topographic characteristics [15] and security issues (the military camp nearby does not allow UAV flights beyond 120 meters). The model of the camera mounted in the UAV was FC6310 with a focal length of 8.8 millimeters. Five Ground control coordinate Points (GCCPs) were recorded through static approach to provide Geo-referenced images. Accurate georeferencing of Aerial photos needs a minimum of four GCCPs [25]. During the image acquisition, 860 photos were captured. However, the number of captured images could vary with the variation in flight height (the higher the flight height the smaller

the number of captured images) [25]. Differential GPS (DGPS) was used to record the GCCPs (the marker-placed coordinates).

In addition to the Aerial image acquisition, a sample trench stored sediment measurement was conducted in the field using a container that has a regular shape and known volume. In the orthophoto 1560 number of trenches was delineated and their area was calculated in ArcGIS using calculate geometry functions. 37 trenches were also selected based on a stratified random sampling technique to measure the stored sediment at the field level. The field-based stored sediment measurement was conducted in January 2022. The sample trenches stored sediment volume has been measured by digging the sediment in the sample trenches to the initial depths and excavating the sediment to the known volume container

2.3. Photogrammetric Aerial image processing

In this study, Agisoft Photoscan software is employed. Agisoft Photoscan which currently called Agisoft Metashape is a very important tool for the photogrammetry pipeline [33]. The Aerial photos were processed in Agisoft PhotoScan professional software which was adopted by Torres-Sanchez et al., [34]. The software is preferred as it could produce more reliable results compared to other software such as Pix4D [25, 35] since camera calibration is automatically following photo alignment. Photogrammetric image processing is a preliminary process to provide high-resolution orthophoto and DTM. Agisoft Photo Scan Professional software works through the principle of structure from motion (SFM) [36, 37]. The photo-alignment is the first step of the photogrammetric image process. The result of that step gives sparse three-dimensional (3-D) point clouds. The next step in this process was locating the markers of the Ground control points (GCPs) on the images and entering the corresponding GCCPs. After placing the markers, the camera orientation was recalculated; possible distortion was corrected and a dense point cloud was constructed. The compacted point cloud is furthermore used to provide the Orthophoto and DTM. The photogrammetric UAV image processing products (DTM and orthophoto) are used as input in the GIS Arc Map to extract elevation and delineate the area of individual trenches, respectively

2.4. Trench area measurement and sediment volume estimation

In this study, the areas of the trenches were calculated by digitizing their shapes in the GIS Arc Map. The high-resolution orthophoto produced from an image captured in January 2021 played a key role in delineating the boundary of the individual trench (polygon) accurately. The volume of soil stored in the trench was computed by multiplying the individual trench area by its mean depth. In March 2020, 1560 trenches were constructed, with an initial depth of 60 cm, although sediment accumulation influenced the lifespan of the constructed trenches. Sediment storage per year was computed based on the initial depth of the trenches. The rate of sediment storage is influenced by the implemented soil and water conservation measures (area exclosure) in the upper catchment of the watershed. In this study, the effectiveness of the area exclosure in soil loss reduction was evaluated by comparing the accumulated sediment volume for 2021 and 2022. The difference between the initial volume of the trench and the calculated sediment volume using elevation helps estimate the sediment stored in the first year. The elevation difference between the two DTMs was used to estimate sediment accumulation in the second year. Geomorphic change of the constructed trench has been calculated through 'DEM of difference' approach adopted by Jayson-Quashigah et al and then the stored sediment estimation [25]. The 'DEM of difference' computed by subtracting the earlier DTM (the DTM of 2021) from the later DTM (the DTM 2022). The deposited sediment volume is computed by multiplying the 'DEM of difference' or change in DTM (depth of sediment) by the area of the trench.

2.5. Measured and estimated sediment volume comparison

The total estimated sediment volume was the submission of the sediment from the 1560 trenches delineated in the high-resolution orthophoto. The rate of soil loss (soil transported to the trench) was calculated for the two years (2021 and 2022) to investigate the impact of the age of the area exclosure on soil loss reduction. The accuracy of the estimated sediment volume was assessed by using the sediment volume measured in the field. The stored sediment volume was estimated using UAV data and compared with its corresponding sediment volume

measured in the field. The estimated and measured sediment volumes were analyzed using descriptive statistics, scatter plots, Root Mean Square error (RMSE), and t-test

3. Results

3.1. Trench area and stored sediment volumes

The resolution of the generated DTM was estimated to be 7 cm while the orthophotos had a ground resolution of approximately 2 cm. The total area of all the trenches was calculated from the GIS Arc Map and estimated 5494.224 square meters. As the trenches had a dugout in a vertical cross section, most of the structures were rectangular. The top and bottom widths of most trenches were almost equal, except for a few trenches that were constructed at a shallow soil depth. The area of a single trench is estimated as the area of the total cells that lie in the digitized trench (polygon). Thus, the total area of a single trench computed directly in the GIS Arc Map using a calculate geometry function and ranges between 0.95 to 5.26 square meters. The total volume of all numbers of trenches (1560) is 3296.534 cubic meters with a depth of 60 centimeters i.e. sediment unfilled. However, in 2021 (after one year), the average depth of the total stored sediment is 0.2702 m, with a total volume of 1484.5393 cubic meters. After two years, in 2022, the elevation of the sediment increased by 0.0676 m and reached 0.3378 m. The sediment volume stored from January 2021 to January 2022 is estimated to be 371.4095 cubic meters. The total sediment stored within two years after trench preparation is the sum of the sediment measured on January 2021 and January 2022 (1855.9488 cubic meters).

3.2. Measured and estimated sediment volumes

The initial volume of 37 sample trenches before sediment accumulation, that is, empty trenches estimated 70.341 cubic meters. After two years, the volume of the sample trench stored sediment was estimated using DTM and obtained 25.1394 cubic meters. However, the stored sediment measured in the field traditionally by four people in 15 days obtained 25.5878 cubic meters. The calculated RMSE of the two measurement results ranges from ± 0.001 to ± 0.1371 cubic meters. The RMSE indicates the deviation between the estimated and measured sediments. The overall difference between the sediment volume calculated from UAV data and sediment volume measured in the field was ± 0.4484 cubic meters. Two years after trench establishment, the stored sediment calculated from the UAV-data deviated from the volume measured in the field by 0.4484 cubic meters in a total volume of 70.341cubic meter trenches (total area = 117.234 square meters with an average depth of 0.6 m). After two years, 45.201 cubic meter volume of trenches remained unfilled.

Table 1. Measured and calculated sediment volumes deposited in the trenches

Statistics	Area(m^2)	Average depth-2021(m)	Average depth-2022(m)	Sediment volume-2021(m^3)	Sediment volume-2022(m^3)	Total sediment volume-2022(m^3)	Measured sediment volume-2022(m^3)	Delta difference
Minimum	0.9563	0.1095	0.0333	0.1351	0.0351	0.1701	0.1737	± 0.001
Maximum	5.2638	0.3164	0.0641	0.9413	0.2599	1.0583	1.0510	± 0.1371
Mean	3.1684	0.1786	0.0368	0.5617	0.1177	0.6794	0.6915	± 0.0262
Sum	117.2344	6.6095	1.3648	20.7839	4.3557	25.1395	25.5882	± 0.97

The volumes of the sediment measured in the field were higher than those calculated from the UAV data, although some of the trenches (trench numbers 5, 12, 19, 28, 34, 35, and 36) had smaller volumes (Fig. 1).

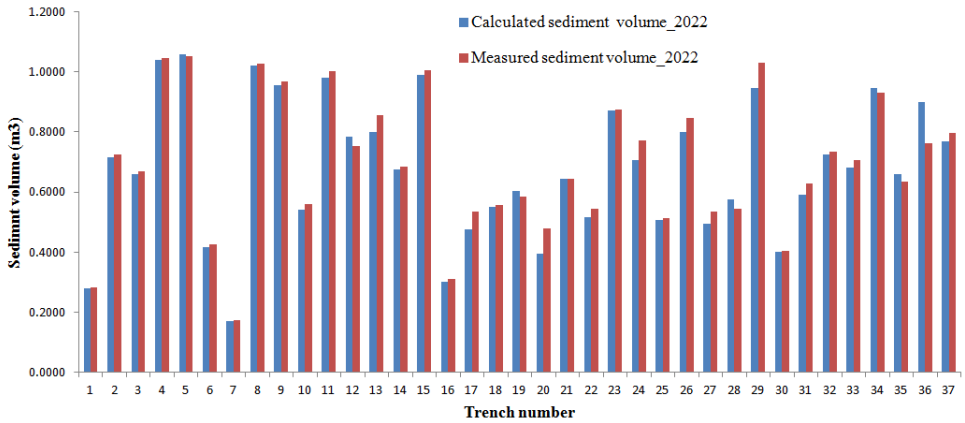

Figure 1. Trench number and stored sediment volume.

There was a strong relationship between the estimated and measured volumes of sediment stored in the trenches (Fig. 2). The scatter plot coefficient of determination (R^2) was 0.97, whereas the correlation.

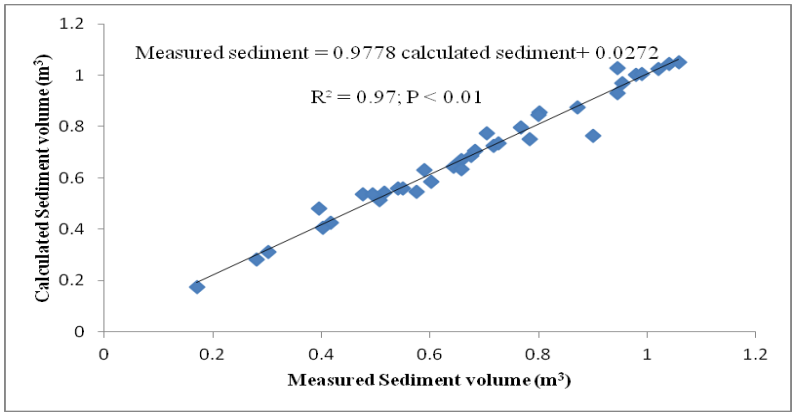

Figure 2. Scatter plot of the measured and calculated sediment volumes.

The result of the P (T<=t) two-tail p-value is 0.82, indicating that there is no significant difference between the calculated and measured sediment deposited in the trenches at the 95% level of confidence.

3.3. Age of Area exclosure and lifetime of trenches

The aim of the constructed trenches in the study area was to store the surface runoff. In addition, stored surface runoff increases the infiltration capacity of the soil and the growth of plants. However, the constructed trench lifetime is influenced by the siltation problem. The volume of the sediment stored in the sample (37 trenches) in the first and second years after trench construction were 20.3879 and 4.3557 cubic meters, respectively (Table 1). In the two-year service period, the surface runoff storage capacity of the constructed trenches decreased from 70.341 to 45.201 cubic meters (64.26%) (Table 1). This result implies that if the area exclosure does not improve the current status of land cover, the lifetime of the trenches will last. Maintenance of soil and water conservation structures is important for sustainable watershed management. Therefore, 35.7% of the water harvesting structures (trenches) in the area exclosure requires maintenance after two years of service for sustainable surface runoff management.

4. Discussion

To the best of our knowledge, this study is the first to evaluate the effectiveness of area exclosure on soil loss reduction using a photogrammetric UAV. In the study area, trenches were constructed for surface runoff harvesting, and area exclosure was implemented to reduce soil erosion. UAV-based sediment assessment and

evaluation of the effectiveness of the area exclosure on soil erosion reduction were conducted. The application of UAV for trench-stored sediment volume estimation is an innovative technique, although different researchers have used the UAV-DTM for different applications [21, 23, 24, 27]. In this study, all trench identification and delineation were performed using UAV in a manner similar to the identification and mapping of suspended sediment concentrations in a river using UAV conducted by Larson et al. [38]. Although UAV are important in both sediment volume measurement and suspended sediment concentration mapping, the sensors mounted on the board were different. In this study, the sediment volume was estimated using an RGB camera, while suspended sediment identification and mapping were performed using a MicaSense Sequoia sensor.The volume of sediment stored in trenches in the first evaluation year (2021) (1484.5393 cubic meters) is higher than that in the second evaluation year (2022) (371.4095 cubic meters). At the age of the area, exclosure increases the rate of soil removal from the catchment, or sediment stored in trenches decreases. This is because of the growth of grass and vegetation after area exclosure, which hinders sediment transportation [12]. Similarly, Peternel et al. [39] conducted landslide monitoring using a photogrammetric UAV in Slovenia. The results of this study revealed that area closure reduced the rate of soil loss. A similar study by Melaku et al. [40] revealed that soil and water conservation measures led to a significant reduction in sediment yield (28-38%) in the Northern Ethiopian highland watersheds. In this study, the only causes of soil loss reduction assumed the area exclosure, considering the analogous amount, distribution, and intensity of rainfall in the assessment years. Climate variability and climate change can influence the intensity of rainfall and its erosivity, which can increase or decrease sediment deposition against area exclosures [25]. In the future, climate variability and changes should be considered before conducting dynamic sediment measurements. The change in the stored sediment analysis supports the contribution of area exclosure to soil loss reduction and the estimation of the service year of the constructed trenches before breaching.

The photogrammetric UAV-based sediment estimation conducted using the DTM difference and orthophoto was similar to the perpendicular sediment profiles generated by Jayson-Quashigah et al. [25] in the Volta Delta coast in Ghana. Additionally, Pitman et al. [41] conducted a survey using UAV to characterize cusp parameters (spacing, amplitude, and depth) and linked cuspate morphology, such as horns and bays, to surface sediment texture. Photogrammetric UAV offer a relatively easy and effective way to supplement the traditional methods of sediment volume estimation [22]. The photogrammetric UAV- and GIS-based evaluation of the area exclosure is promising, similar to the sediment yield from the watershed predicted by Jain et al. [26]. Although soil erosion and stored sediment in different watersheds varied (due to differences in slope, land cover, land use, and climate), stored sediment volume estimation using photogrammetric UAV minimizes the challenges of conventional sediment yield measurements [15, 26]. Nevertheless, the rate and stored sediment volume of various watersheds have spatial variability, and stored sediment measurement in a simple way is important for evaluating the effectiveness of watershed management. Land restoration after area exclosure reduces soil erosion and surface runoff velocity [42]. The average sediment volumes measured traditionally and calculated using photogrammetric UAV data were 0.6915 and 0.6794 cubic meters, respectively (Table 1), and the mean deviation was insignificant. The small variation between the two methods of sediment volume measurement may be due to the error occurring during stored sediment excavation or during DTM generation. During the excavation of stored sediment, either extra soil could be added from the original surface (exaggerate the estimated sediment volume) or soil loss from the stored sediment volume (underestimate of the estimated sediment volume). The calculated and measured sediment volume deviations ranged from ± 0.001 to ± 0.1371 cubic meters (Table 1). Similarly, the accuracy of UAV-derived DSMs was assessed against equivalent topographic profiles via RMSE, and found to be < 0.21 [43]. The results revealed by Lowe et al are in line with the results obtained in this study [43]. Another study done by Lizarazo et al for detection and mapping of land surface elevation changes from UAV-based imagery in a quarry zone and revealed a RMSE of 0.15 to 0.25 meters which indicates DTM change is strongly close to the reference [44]. The sources of error between the calculated and measured sediment volumes could be the uncertainty associated with the stored sediment measurement on the ground and the recorded GCP positions. Sediment measurements on the ground are accurate; however, it is difficult to separate the stored soil from the original/base soil. The traditional method of stored sediment volume measurement is labor-intensive and time-consuming since 25.5878 cubic meters of stored sediment measurement by four people

requires fifteen days. The other challenge observed during the traditional method of sediment measurement is the variation between the top and bottom widths of some trenches. The variation between the top and bottom widths of the trenches negatively affects the accuracy of the stored sediment measurement because of the difficulty in finding the original/initial depths. In this study, some of the trench bottom and top widths were found to be different; hence, excavating the stored sediment accurately was negatively affected by the mixing of stored sediment and original soil. A few trenches showed a greater amount of stored sediment (Figure 1) when the sediment measurement method was traditional. Although the estimated and measured sediment volumes had small variations in a few trenches, the scatter plot showed a mathematically significant relationship (R2 = 0.97, r = 0.98) (Figure 2). Similarly, the estimated and measured stump height compared with Saad et al. [45] showed a significant relationship with an R^2 of 0.83. The R2 value obtained in this study (Figure 2) revealed a stronger relationship than the R2 value obtained by Saad et al. [45] from trenches that were found in an open area (no obstruction for the point cloud). The stored sediment volume estimation using a photogrammetric UAV applied in this study is important for different reservoir siltation problem assessments [15] and management decisions (stored sediment excavation and erosion control). Therefore, the assessment of the impact of watershed management on soil loss is crucial for the management of constructed trenches and other water-harvesting structures by reducing siltation problems [46, 47]. Evaluating the benefits of structural soil and water conservation measures using UAV remote sensing is a potential and innovative approach for accurately estimating stored sediment [14, 24]. Trench-stored sediment volume estimation using UAV photogrammetry is more accurate and efficient than traditional methods [48] because it can generate high-resolution DTM [49].

In this study, UAV photogrammetry was applied to estimate the sediment volume silted by trenches, similar to some studies conducted to estimate the sediment stored by check dams [14, 51]. Trench-stored sediment volume estimation using UAV photogrammetry is precise and efficient because the life span of the structure is small and requires little historical topographic data. However, the estimation of stored sediment volume in large reservoirs using UAV photogrammetry requires continuous historical topographic assessment. The application of UAV-based sediment volume estimation is important for assessing the impact of soil and water conservation interventions [36, 52, 53]. The practical implications of UAV photogramy-based sediment volume estimation are the ability to quantify precise sediment deposition compared to traditional methods [52]. According to Chang et al. [52], sediment volume estimation using UAV photogrammetry is cost- and time-efficient compared to traditional surveying methods, such as manual sediment volume measurement. The practical implication of UAV photogrametry-based sediment volume estimation is its application in remote areas that are difficult to reach. The focus of this research is the analysis of sediment volume change over time using UAV photogrammetry, as this is important for appropriate decision-making related to erosion control [36].

Sediment volume estimation using UAV photogrammetry has various sources of error and uncertainty [27, 36, 53]. Some of the errors and uncertainties are inaccurate GCPs, undulated topography and dense vegeta-tion; blur image acquisition, photo misalignment, coarse resolution images, and camera calibration errors. Climate change and variability can affect the effectiveness of area exclosures because the amount, distribu-tion, and density of rainfall cause variations in the rate of soil erosion. Accurate trench-stored sediment vol-ume estimation depends on the accuracy of the generated DTM. Differences in elevation and historical ter-rain data limitations may cause nonnegligible errors [14]. UAV photogrammetry in steep slopes and dense vegetation-covered areas DTM generated from an RGB camera is not accurate because interpolation in un-dulated and long-distance topography is inaccurate and requires a solution [53]. For accurate sediment vol-ume estimation using UAV photogrammetry, it is essential to consider and mitigate the potential sources of errors and uncertainties. The potential sources of errors and uncertainties can be minimized through careful planning and execution of data collection, proper positioning of GCPs, image processing and quality control, and validation against ground-truth data.

Author Contributions: The First author, Tiegst Hadush; was the principal investigator who designed the research and wrote the proposal, taking the study from inception through fieldwork, data analysis, and writing manuscript. His role includes conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources provision, software usage, supervision, validation, visualization, and writing original drafts. The co-authors Atkilt Girma and Amanuel Zenebe contributed to the work and their role includes project administration, resources, supervision, visualization, writing review and editing. All authors read, revised and approved the final content.

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Impact of Biophysical Soil and Water Conservation Measures on Soil Carbon and Nitrogen Pools in Tigray, Ethiopia

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Abstract: Biophysical soil and water conservation measures are vital for mitigating soil erosion, enhancing soil quality, and promoting sustainable land use in hilly landscapes. This study examines the impacts of biophysical soil and water conservation interventions on labile and recalcitrant carbon and nitrogen pools in the Tigray region of Ethiopia. A total of 48 composite soil samples were collected from treated and untreated sub-watersheds, considering variations in management status, slope position, soil depth, and distance from conservation structures. The analysis revealed that soil and water conservation practices significantly enhanced soil organic matter, particularly at lower slope positions where nutrient deposition is higher. However, their effectiveness declined with increasing distance from soil and water conservation structures, indicating spatial limitations in nutrient enrichment. These findings highlight the need for optimized planning in the placement and spacing of conservation interventions to enhance soil-related and ecological benefits in degraded hilly sub-watersheds. By strengthening soil nutrient pools and improving soil organic matter dynamics, biophysical soil and water conservation practices contribute to climate change mitigation and land restoration in degraded sub-watersheds. The study underscores their crucial role in enhancing soil fertility and supporting ecological restoration, offering valuable insights for land rehabilitation strategies in semi-arid, erosion-prone regions.

Keywords: distance, management, slope position, soil depth, soil organic matter fractions, treated land

1. Introduction

Land degradation, driven by soil erosion and depletion of soil nutrients, is a major global environmental challenge that threatens ecosystem functions, biodiversity, and sustainable livelihoods, especially in semi-arid regions [1–3]. In Ethiopia, soil erosion has significantly contributed to reduced soil fertility and persistent poverty, affecting agricultural productivity and environmental health [4,5]. Soil and water conservation (SWC) practices are widely implemented to mitigate erosion, improve soil quality, and restore degraded landscapes. These measures increase soil organic carbon (SOC), total nitrogen (TN), moisture retention, and biomass, thereby enhancing ecosystem stability [6–9]. However, the effects of biophysical SWC on labile and recalcitrant pools of soil carbon and nitrogen, which are crucial for soil fertility and nutrient cycling, remain underexplored, especially across different slope positions and soil depths [10–12]. Understanding these dynamics is essential for optimizing conservation strategies and advancing climate change mitigation efforts through carbon sequestration. Therefore, this study aims to (1) quantify the effects of management (treated vs. untreated land), slope position, and soil depth on labile and recalcitrant carbon and nitrogen pools; (2) analyze how slope position, soil depth, and distance from the SWC structures influence these pools; and (3) evaluate the relationships between total soil carbon and nitrogen and their labile and recalcitrant fractions. Our findings demonstrate significant improvements in soil nutrient storage, particularly at lower slope positions and upper soil layers, emphasizing the need for targeted management to maximize ecological benefits.

2. Materials and Methods

2.1. Study Area and Site Selection

This study was conducted in the Atsbi-Wenberta district of Tigray, northern Ethiopia (13°30′–13°45′ N; 39°30′–39°45′ E), at altitudes ranging from 2,300 to 3,200 m a.s.l. The area features a semi-arid climate with an average

annual rainfall of 635 mm, and mean annual temperatures ranging from 6.1°C to 22.8°C. The landscape includes hilly, valley, and mountainous terrain, with dominant soil types such as Leptosols, Regosols, Cambisols, and Fluvisols. Farming is mainly rain-fed mixed crop-livestock systems.

A total of eight micro-watersheds (four treated and four untreated) were selected from Kalamin and Barka-Adisbha villages using stratified random sampling based on agroecology, conservation history, and topographic features. Treated sub-watersheds had physical (trenches, stone and soil bunds, small and large half-moons, deep trench, hill side terrece etc.) and biological (exclosures, plantations) SWC practices, while untreated lands were open and grazed.

2.2. Experimental Design and Soil Sampling

A factorial randomized complete block design was used. Two experimental groups, each with 48 plots, were established: Group 1**:** Combined management (treated vs. untreated)**,** slope position (upper, middle, lower)**,** and soil depth (0–30 cm, 30–60 cm)**.** Group 2**:** Combined distance from SWC structure (0–4 m, 4–8 m)**,** slope position**,** and soil depth.

A line transect system was employed across slope positions, with 40 m × 40 m plots laid at 20 m intervals for each and 5 m from the watershed edge. Composite soil samples (1 kg) were collected per treatment from each slope–depth–management/distance combination. Additionally, 24 undisturbed samples were collected for bulk density using a core sampler (10 cm height, 7.2 cm diameter).

2.3. Laboratory Analysis

Soil samples were analyzed at the Mekelle University soil laboratory. Total organic carbon (TOC) was determined using the Walkley and Black titration method [13], and total nitrogen (TN) was analyzed using the Kjeldahl digestion and distillation method [14]. Labile and recalcitrant fractions of carbon and nitrogen (Pools I and II) were determined using established fractionation procedures described in prior studies [15].

2.4. Statistical Analysis

Collected data were subjected to factorial ANOVA to test the effects of slope position, management, soil depth, and distance from SWC structures on soil carbon and nitrogen pools. Significant differences among treatment means were separated using Tukey's HSD test at $p < 0.05$. All statistical analyses were conducted using R software version 4.3.1 [16]. Prior to analysis, data normality and homogeneity of variance were checked using the Shapiro–Wilk and Levene's tests, respectively.

3. Results: Effects of Integrated SWC Measures on Soil Nitrogen and Carbon Pools

3.1. Soil Nitrogen Pools

Biophysical soil and water conservation (SWC) measures significantly increased both labile and recalcitrant nitrogen pools ($P < 0.001$, Table 1). Treated lands showed a 25.4% and 24.7% increase in labile and recalcitrant nitrogen, respectively, over untreated lands. Lower slope positions and surface soils (0–30 cm) also had higher nitrogen pools. Notably, a 48.9% increase in labile nitrogen and 47.4% increase in recalcitrant nitrogen were recorded in treated lands at lower slopes and 0–30 cm depth compared to the control. Interaction effects among management, slope, and depth were all significant.

Table 1. Mean squares analysis of variance for the effects of management, slope position, soil depth, and their interaction on soil labile nitrogen, recalcitrant nitrogen, labile carbon, and recalcitrant carbon

Source of variations	Labile Nitrogen	Recalcitrant Nitrogen	Labile Carbon	Recalcitrant Carbon
Replication (3)	(2.14*10-8) *	0.0272**	0.000009**	15**
Management (1)	(1.08*10-6) ***	1.2637***	0.003310***	5167***
Slope (2)	(4.02*10-8) **	0.0334**	0.000011**	17**

Depth (1)	(2.70*10-7) ***	0.3754***	0.002139***	3336***
Management x Slope (5)	(2.343*10-7) ***	0.27104***	0.0006665***	1040.4***
Management x Depth (2)	(2.054*10-7) ***	0.25326***	0.0010937***	1705.9***
Slope x Depth (2)	(1.870*10-9) ns	0.00031ns	0.0000024*	3.8*
Management x Slope x Depth (11)	(1.445*10-7) ***	0.16941***	0.0005024**	784.0***

*** difference is significant at the 0.001 level (2-tailed), ** is significant at the 0.01 level (2-tailed), * is significant at the 0.05 level (2-tailed), and "x" represents an interaction between factors.

3.2. Soil Carbon Pools

Labile and recalcitrant carbon pools were significantly improved by SWC. Treated lands had a 60.4% increase in both labile and recalcitrant carbon ($P < 0.001$, Table 1). Similarly, surface soils and lower slope positions showed higher values, with labile carbon increasing by 45.8% and recalcitrant carbon by the same percentage in surface soil over subsurface. The highest increase (162.9% in labile and 163% in recalcitrant carbon) was observed in treated, lower-slope lands at 0–30 cm depth.

3.3. Effect of Distance from SWC Structures

The interaction effect of slope position and distance from the SWC structure on soil labile nitrogen was significant ($P < 0.001$, Table 2). Proximity to SWC structures enhanced soil nutrient pools: at 4 m compared to 8 m, labile and recalcitrant nitrogen increased by 13.1%, while labile and recalcitrant carbon increased by 43.3%.

Table 2. Mean squares of analysis of variance for the effects of slope positions, distance from SWC structure, and soil depth on soil labile nitrogen, recalcitrant nitrogen, labile carbon, and recalcitrant carbon.

Source of variations	**Labile Nitrogen**	**Recalcitrant Nitrogen**	**Labile Carbon**	**Recalcitrant Carbon**
Replication (3)	$(6.020x10^{-8})^{***}$	0.0742^{***}	0.0000039^{ns}	6^{ns}
Slope (2)	$(5.200x10^{-8})^{***}$	0.0641^{***}	0.0000223^{***}	35^{***}
Distance (1)	$(3.476x10^{-7})^{***}$	0.4284^{***}	0.0021316^{***}	3325^{***}
Depth (1)	$(4.535x10^{-7})^{***}$	0.5589^{***}	0.0019883^{***}	3102^{***}
Slope x distance (5)	$(9.09x10^{-8})^{***}$	0.11202^{***}	0.0004358^{***}	679.8^{***}
Distance x depth (3)	$(2.81x10^{-7})^{***}$	0.3463^{***}	0.0013826^{***}	2156.9^{***}
Slope x depth (5)	$(1.118x10^{-7})^{***}$	0.13782^{***}	0.0004071^{***}	635.1^{***}
Slope x distance x depth (11)	$(8.652x10^{-8})^{***}$	0.10662^{***}	0.0003818^{***}	595.6^{***}

*** difference is significant at the 0.001 level (2-tailed), ns = not significant.

The combined influence of closer distance (4 m), lower slope position, and surface soil layer (0–30 cm) led to a 39.6% increase in labile nitrogen, a 127.1% increase in labile carbon, and a 39.5% increase in recalcitrant nitrogen.

3.4. Relationships of Soil Labile and Recalcitrant Nitrogen and Carbon Pools with Total Nitrogen and Organic Carbon

Both labile and recalcitrant nitrogen and carbon positively correlated with total nitrogen and organic carbon contents. As total nitrogen increased from 1 to 3 mg/g, labile nitrogen rose from 0.00125 to 0.00170 mg/g, and recalcitrant nitrogen from 1.4 to 1.8 mg/g ($P<0.05$, Figures 1a and 1b). Similarly, increases in total organic carbon from 21 to 82 mg/g led to significant rises in labile carbon (0.02 to 0.047 mg/g) and recalcitrant carbon (22 to 57 mg/g) ($P < 0.05$, Figures 1c and 1d), confirming the enrichment of functional carbon and nitrogen pools under improved SWC practices.

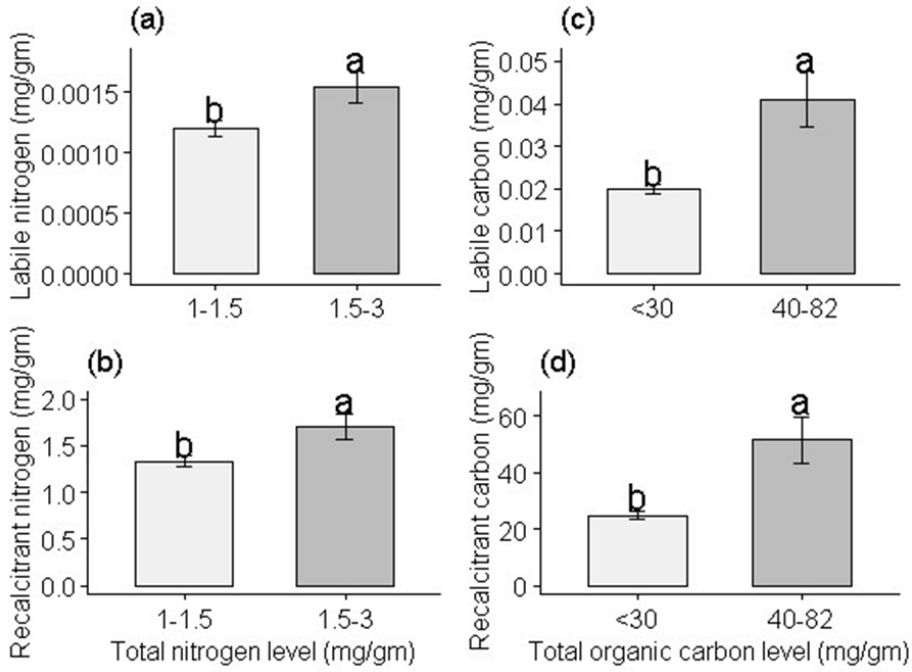

Figure 1. Relationship of labile nitrogen: (a) recalcitrant nitrogen; (b) labile carbon; (c) recalcitrant carbon; (d) with their total nitrogen and total organic carbon contents on the management-based experiment. Figures with different lowercase letters indicate significant differences at $p < 0.05$, while similar lowercase letters indicate insignificance.

As the total nitrogen content increases from 1 to 3 mg/g, both labile and recalcitrant nitrogen fractions also show significant increases ($P < 0.05$). Specifically, labile nitrogen rises from 0.00126 to 0.00170 mg/g, while recalcitrant nitrogen increases from 1.4 to 1.75 mg/g (Figure 2a and 2b). Similarly, total soil organic carbon increases from 26.68 to 40 mg/g, accompanied by an increase in both labile and recalcitrant carbon fractions. Labile carbon increases slightly from 0.023 to 0.025 mg/g, and recalcitrant carbon rises from 28 to 30 mg/g (Figures 2(c) and 2(d)). With a further increase in total organic carbon from 26.68 to 82 mg/g, there is a more pronounced rise in carbon fractions: labile carbon increases from 0.023 to 0.047 mg/g, and recalcitrant carbon increases from 28 to 57 mg/g (Figures 2(c) and 2(d)).

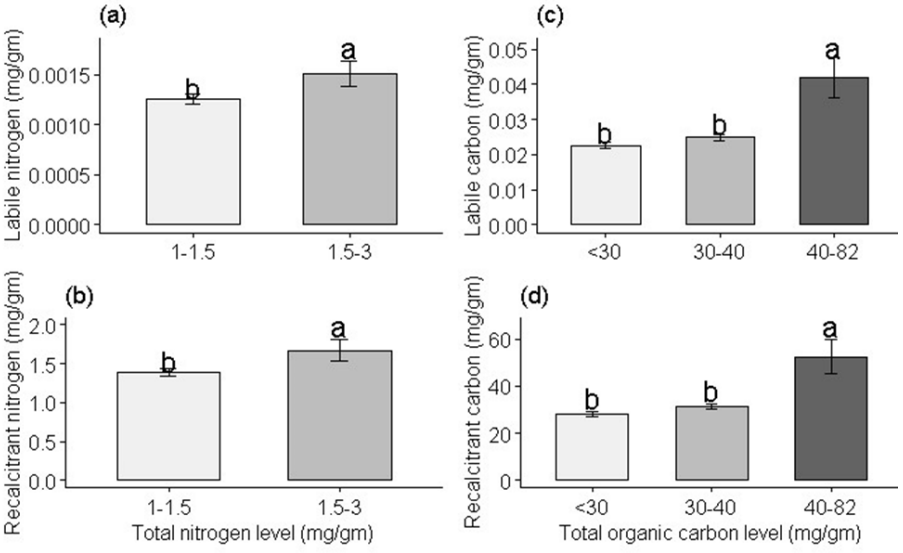

Figure 2. Interaction graph of labile nitrogen (a) recalcitrant nitrogen (b) labile carbon (c) and recalcitrant carbon (d) with their total nitrogen and total organic carbon contents on the distance-based group. Figures with different lowercase letters indicate significant differences at $p<0.05$, while similar lowercase letters indicate insignificance

4. Discussion

4.1. Effects of SWC Practices, Slope Position, and Soil Depth on Soil Carbon and Nitrogen Pools

Biophysical soil and water conservation (SWC) practices significantly enhanced labile and recalcitrant nitrogen and carbon pools, supporting H1. Treated lands showed greater nutrient content, especially in surface layers, due to increased organic matter input and improved stability [17]. The labile nitrogen pool, being more responsive to management, rose notably in conserved plots and correlated with aboveground biomass ($p < 0.001$) [17–19]. Rehabilitated areas supported higher recalcitrant nitrogen due to increased biomass and slower decomposition [17,18], with 86% of total N from the recalcitrant pool and only 13% from the labile fraction [18].

Soil depth significantly influenced nutrient pools (H2), with higher labile and recalcitrant carbon and nitrogen in the 0–30 cm layer, driven by residue accumulation and microbial activity [17–19]. These effects were more prominent in conserved sites due to retained inputs and favorable microclimates.

Slope position had minor effects. While H0 assumed no significant variation, slight increases in SOC and nitrogen at lower slopes suggested deposition and better moisture retention [20], though SWC and depth were stronger drivers.

Carbon pools followed similar trends, with surface concentration linked to organic input and reduced disturbance [17,21]. SOC was higher in treated plots, with labile C comprising about 13% of total C [18]. Ex-closures increased SOC and labile fractions in the topsoil [21], while disturbance promoted microbial access to labile C [17].

Management type influenced nutrient dynamics across land uses. Crop and grazing lands had lower pools [19,22], whereas ex-closures enhanced soil carbon and nitrogen [23]. Ex-closures improved carbon storage and reduced degradation [23]. Labile carbon, though biologically active, is hard to characterize; it is often estimated through decomposition-simulating lab methods [24].

In summary, SWC and soil depth were key drivers of soil nutrient pools, while slope had limited impact—supporting H1 and H2, and rejecting H0. These findings highlight the value of integrated SWC for restoring degraded highland soils.

4.2. Impact of Distance from the SWC Structure on Soil Carbon and Nitrogen Pools

Labile and recalcitrant carbon and nitrogen pools were higher at lower slope positions, especially within 0–4 m of SWC structures and at 0–30 cm depth, compared to distant control sites. This is likely due to sediment deposition, greater residue accumulation, and better moisture near SWC structures. Similar trends were reported by Buraka et al. [20] and Wolde Mekuria et al. [25], who noted higher SOC at lower slopes due to downslope topsoil movement. Increased vegetation and reduced sunlight further enhanced SOC in these areas [20]. Total nitrogen also increased downslope, likely due to organic matter loss from upper slopes via erosion [25–27].

Distance from SWC structures strongly influenced nutrient pools, with the highest labile and recalcitrant carbon and nitrogen found within 4 m of the structures, in line with increased total C and N in conserved soils [17,28]. Fertility indicators peak near embankments (0.00–0.25 m) and decline with distance [29,30]. SWC structures boost soil nutrient retention and productivity [31], with soil bunds particularly effective at reducing runoff and preserving soil properties [32].

4.3. Correlation of Soil Nitrogen and Carbon Pools with Total Nitrogen and Total Organic Carbon Contents

Labile and recalcitrant nitrogen pools were strongly correlated with total nitrogen, suggesting it is a major driver of these fractions. Ahmed et al. [19] reported similar trends, with decreases in labile and recalcitrant nitrogen paralleling total nitrogen declines across land-use types, and recalcitrant nitrogen forming the bulk of total nitrogen stocks. Likewise, higher labile and recalcitrant carbon contents were linked to increased TOC, indicating it as the main source. Ferraz de Almeida et al. [17] observed these carbon pools were concentrated at the surface due to organic inputs. McLauchlan and Hobbie [24] found labile carbon increases aligned with TOC rises, while Belay-Tedla et al. [18] emphasized the dominance of recalcitrant carbon in total carbon stocks.

However, the interactive effects of TOC and total nitrogen on labile and recalcitrant pools in SWC-managed lands remain understudied. Future research should clarify these relationships to better inform nutrient cycling and soil fertility under conservation practices.

4.4. Future Research Directions

While this study underscores the impacts of SWC, slope, and soil depth on soil nutrient pools, further research is needed to:

1. Monitor long-term changes in labile and recalcitrant pools under varying climate conditions.
2. Investigate microbial and enzymatic roles in carbon and nitrogen stabilization.
3. Examine how vegetation types and root systems influence nutrient pools across SWC and slopes.
4. Map spatial variability of nutrient pools at watershed scales using remote sensing.
5. Assess interactions between nutrient pools and soil physical properties to better understand stabilization processes

5. Conclusions

Soil nitrogen and carbon pools are significantly influenced by management practices, slope position, distance from soil and water conservation (SWC) structures, and soil depth. Treated lands exhibit higher total organic carbon and nitrogen, primarily from recalcitrant pools. Carbon and nitrogen concentrations increase closer to SWC structures and are more abundant in surface soil layers. Strong positive correlations between labile pools and total organic carbon and nitrogen highlight the importance of surface soil in nutrient cycling. Understanding these interactions is crucial for effective SWC design and sustainable soil fertility management. Further research should explore spatial variability, microbial dynamics, and region-specific soil characteristics to optimize conservation strategies.

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Impact evaluation of stone bund effectiveness on selected soil properties and wheat productivity in rain-fed croplands of the Tigray highlands, northern Ethiopia

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Abstract: Soil erosion and degradation are major concerns for sustainable agriculture in the highlands of Ethiopia, negatively affecting soil and crop productivity. To address this, efforts are being made to implement stone bunds. Stone bunds, widely used for conservation, are hypothesized to improve soil properties and enhance farming output over time. This study examines the impact of the stone bund age on certain soil properties and wheat yield in the croplands of the Adi Awulie, Adi Ginbot, and May Muk microwatersheds in southern Tigray, northern Ethiopia. Soil and crop data were collected from eight croplands, including four that had been bunded with stone bunds for 6, 14, 15, and 25 years and four un-bunded plots. The results revealed that stone bunds reduced soil bulk density (Bd) and increased soil moisture, pH, total nitrogen (N), organic carbon (OC), potassium (K), available phosphorus (P), and cation exchange capacity (CEC), compared to plots that were left un-bunded. Wheat grain yields were significantly higher by 43.69%, 21.28%, 47.62%, and 67.42% for bunds aged 6, 14, 15, and 25 years, respectively. Overall, results show that selected wheat parameters were significantly correlated ($p < 0.01$) with selected soil properties. These findings highlight the importance of stone bund techniques in mitigating land degradation and addressing agricultural and environmental sustainability, offering valuable insights for future land management strategies and local farmers targeting to optimize crop harvests in the region.

Keywords: Soil degradation, soil water conservation, stone bunds, sustainable land management, sustainable agricultural practices, soil properties, wheat yield, Ethiopia

1. Introduction

Soil is a vital and dynamic system that acts as a store for essential nutrients such as organic carbon (OC), nitrogen (N), and phosphorus (P), crucial for agricultural production. However, the deposition and transformation of agricultural soils can disrupt the carbon cycle and nutrient availability [1]. One of the most significant threats to soil quality is erosion, primarily caused by human activities such as tillage, which depletes organic matter (OM) and key nutrients, including phosphate and N, thereby reducing agricultural productivity [2]. Soil erosion, exacerbated by factors like slope length, climate, and topography, is a major environmental challenge in both industrialized and developing nations [3,4]. In Ethiopia, soil erosion, particularly in the highlands, contributes to significant land degradation, leading to loss of fertility and biodiversity [5]. This has become one of the primary barriers to agricultural productivity in the region [6].

Land degradation in Ethiopia is widespread, with large areas becoming unsuitable for agricultural use [7]. In the northern and central highlands of Ethiopia, soil erosion has made approximately 50% of the land unfit for agriculture, severely impacting cereal production [5,6,8]. Erosion-induced nutrient loss is a primary factor behind the failure of agricultural systems, resulting in reduced crop yields and economic losses [9]. For example, Ethiopia has lost an estimated 162 million US$ annually in crop income due to land degradation [6]. Similarly, soil degradation has caused a 25% reduction in the yield of rain-fed wheat compared to the levels achieved over the past 30 years. This decline has resulted in a 3.8% loss in Ethiopia's GDP [6]. Human activities, such as poor agricultural practices and inadequate land management, have worsened the problem. Soil degradation in the form of physical, chemical, and biological factors has led to a decline in soil fertility, reducing the potential for agricultural production and negatively impacting livelihoods [10–12]. Soil erosion causes fluctuations in soil nutrients, which negatively affect crop productivity [13].

In response to these challenges, the Ethiopian government and various organizations have invested heavily in soil and water conservation (SWC) measures to combat soil erosion and improve soil fertility [14]. Since the 1970s

and 1980s, various conservation strategies [15], such as stone bunds and earth embankments, have been implemented in the country, especially in areas prone to erosion [10]. These conservation efforts have shown positive impacts on soil physical and chemical properties, with significant improvements in soil texture, OM, and nutrient levels in conserved areas compared to un-conserved ones [16–21]. Research has demonstrated that SWC measures enhance water retention and improve soil fertility indicators like OC and N levels [17-20,22-31]. However, there is a need for more long-term studies on the impact of SWC measures on soil properties and productivity [19,23,28,32–37].

Despite these efforts, the full potential of SWC measures has not been realized due to the lack of integration with local land management practices. In some regions, SWC structures have not been effectively incorporated into farmers' regular agricultural routines, limiting their long-term benefits [10]. Recent studies have highlighted the importance of assessing the age of SWC structures, such as soil bunds and stone-faced soil bunds, and their impact on soil properties across different slope positions [37]. In addition, the age of stone bunds in Tigray has shown significant effects on soil fertility, slope gradients, and crop yields over time [33]. However, information on how the age of these structures influences soil quality, particularly in micro-watersheds, is still lacking. There is a deficiency of age-related analysis on the stone bund efficiency on soil properties and crop yields over time. This study aims to fill this gap by assessing the long-term impacts of stone bunds of varying ages on soil physical and chemical properties and wheat yield in rain-fed croplands of southern Tigray, with a focus on providing insights for better policy design and land management practices. Therefore, the objectives of this study are;

a. To investigate the effectiveness of stone bunds in improving soil physical and chemical properties, and wheat yield at different age categories.
b. To assess the effectiveness of stone bund ages in improving soil physical and chemical properties, and wheat yield at different slope categories.
c. To investigate the correlation between soil physical and chemical properties and wheat parameters in the study area.
d. To contribute to policy designs on the effectiveness of stone bunds work in the study areas.

2. Materials and Methods

1.1. Description of the study

The study was conducted in the highlands of southern Tigray, specifically in Emba Alajie and Endamehoni districts, in northern Ethiopia. Rain-fed cultivation is the dominant form of cultivation in southern Tigray, which accounts for 47% of land use [38], in which wheat is one of the dominant stable crops. The soil type and coverage in the districts vary within land slope and elevation. The dominant soil types are leptosols (69.07%), cambisols (27.72%), and vertisols (3.07%). In Emba Alajie woreda, leptosols are the most common, covering 86.22% of the area, followed by cambisols and vertisols [39]. Similarly, in the Endamehoni district, leptosols cover 63.9% of the land, followed by cambisols and vertisols. The soil characteristics in Endamehoni are influenced by various factors, including the slope gradient and land management techniques [38].

2.2. Data collection approaches and statistical analysis

A multi-stage sampling technique was used to select districts, representative kebeles, and watersheds. This study covers croplands bunded with varying ages (6, 14, 15, and 25 years) and adjacent un-bunded plots, providing a comparative situation to evaluate the long-term impacts of bunds on soil properties and wheat productivity. A comparative field experiment was conducted on bunded croplands and their adjacent un-bunded croplands, and a stratified sampling across three slope positions was conducted to capture spatial variability. In this case, we employed a clinometer and GPS coordinates to measure slope gradients and classify study sites accurately.

Disturbed soil samples were collected at 0-30 cm layers using an auger, and core samples for undisturbed soils. Wheat samples were collected by using agronomic procedures from the areas soil samples were collected.

Descriptive statistics (mean ± standard deviation) were employed to summarize the results of soil properties and wheat productivity. Three-way analysis of variance (ANOVA) was also used to test the effects of conservation

status (Stone bunded vs. Un-bunded), stone bund age, and slope position on soil properties and wheat productivity. In this case, we used Shapiro-Wilk and Levene's tests to check the assumptions of normality and homogeneity of variance, respectively.

3. Results

1.2. Effect of stone bund ages, slope positions, and conservation status on soil properties

Soil properties differed significantly ($p < 0.05$) across stone bund ages, with the highest average soil parameters recorded on croplands bunded for 15-year-olds and the lowest on the rest stone bund ages. As compared to the bunded croplands, lower mean values of soil moisture content, OC, N, P, K, and CEC were recorded in adjacent un-bunded croplands. Slope positions also had a significant effect on soil properties, which decreased as the steepness of the slope increased. Conversely, higher soil BD was observed on the un-bunded croplands. The lowest soil Bd was observed on the 25-year stone-bunded cropland. The result of the descriptive statistics showed that soil properties differed significantly across stone bund ages, slope positions, and conservation status (Table 1).

The soil pH, OC, N, P, and K showed significant differences across the treatments (Table 1 and Fig. 1). The lowest pH, OC, N, P, and K were observed in the un-bunded cropland, whereas higher values were found in croplands bunded with stone bunds. In our study, the mean soil pH ranged from 7.61 to 7.97, consistent with the findings of Tanto and Laekemariam [19], who reported a rise in pH from 5.87 to 6.60 in treated lands compared to untreated croplands. Additionally, Reda et al. [40] showed that soil pH is influenced by management practices, with an average pH of 7.64 and a range from 7.04 to 8.9 recorded in southern Tigray.

The study found that soil pH was significantly influenced by the slope positions of croplands with stone bunds that were 6 and 14 years old. However, no significant variation in pH was observed for croplands with stone bunds that were 15 and 25 years old (Table 1). This aligns with previous studies [9,21,28,34], which reported that soil pH was not statistically affected by the slope positions of bunds. In contrast, other studies [15,20,41] found significant differences in soil pH across slope positions. For example, Belay and Eyasu [17] noted that lower slope positions had significantly higher soil pH compared to upper slopes due to the deposition of fine soil particles, organic matter, and exchangeable bases in the lower areas, whereas upper slopes were more prone to erosion.

The study also revealed significant differences in soil OC, total N, and available P among different treatments. The highest levels of OC, N, and P were found in croplands with stone bunds aged 6, 14, 15, and 25 years compared to adjacent plots without conservation measures (see Table 1). This variation in OC and total N content is likely due to the higher organic matter in fields with stone bund practices. Similar findings [17,34,42] reported higher total N and Available P in conserved lands compared to non-conserved ones. Furthermore, Challa et al. [9] observed higher total N (0.24%) and lower total N (0.17%) in conserved and non-conserved lands, respectively. In another case, Belay and Eyasu [17] also reported higher available P (3.65 mg kg^{-1}) in stone bund-treated plots, compared to lower values (1.78 mg kg^{-1}) in untreated plots. This is consistent with other findings [19,22] which also observed higher total N and P in conserved plots. Watershed management in northwest Ethiopia has also been shown to significantly improve these soil properties [43]. Moreover, Belay and Eyasu [17] found a notable increase in total N in farmland treated with stone bunds, with a significant difference between conserved (0.07%) and non-conserved (0.03%) soils ($p = 0.001$).

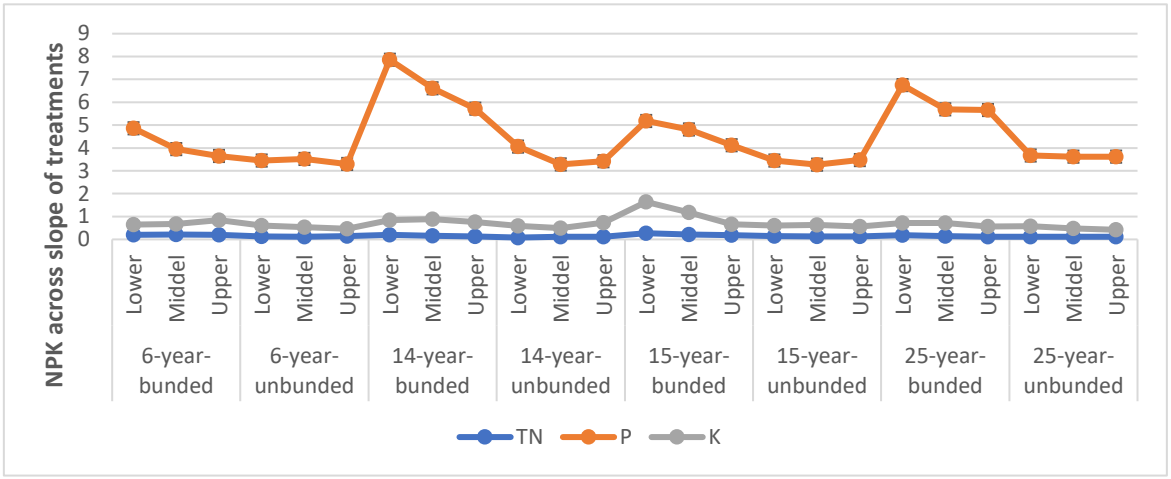

Figure 1. Total nitrogen (TN), available phosphorus (P), and potassium (K) distribution by slope position for bunded and unbunded cropland plots. Lower slopes show significantly higher soil NPK compared to middle and upper slopes, highlighting topographic influence on soil nutrients.

As for slope positions, there was no significant difference in total N between slope positions of stone bunds (Table 1 and Fig. 2). However, some [9,41] found significant variations in total N based on slope gradient, with higher values on lower slopes and lower values on upper slopes. The current study also found that total N and P decreased as one moved from lower to upper slope positions in stone bund-treated croplands. This aligns with those findings [20,28,37,44] that all observed higher levels of total N and P in lower slopes compared to upper slopes. As Sinore and Doboch [24] explained, lower slopes are depositional areas, while upper slopes are more prone to soil erosion, leading to nutrient loss. Moreover, the mean OC content was significantly affected by slope positions in stone bunds aged 14, 15, and 25 years, consistent with the findings [15,27]. Soil CEC was significantly affected by slope positions, with the highest CEC observed on the lower slope of the bunded croplands.

Table 1. Summary statistics (mean ± SD) of soil bulk density (BD), moisture content (MC), organic carbon (OC), pH (soil reaction), and cation exchangeable capacity across stone bund ages, slope positions, and conservation status

Treatments	Slopes	Conservation status	Bd	MC	OC	pH	CEC
6-year-bunded	Lower	Bunded	1.21±0.03	21.65±0.42	2.37±0.06	7.97±0.06	40.35±0.17
6-year-bunded	Middle	Bunded	1.22±0.03	20.36±0.81	2.33±0.05	7.77±0.06	39.82±0.13
6-year-bunded	Upper	Bunded	1.29±0.05	19.74±0.26	2.28±0.05	7.80±0.00	39.38±0.22
6-year-unbunded	Lower	Un-bunded	1.35±0.06	17.70±1.96	1.47±0.26	7.70 ±0.00	37.95±1.82
6-year-unbunded	Middle	Un-bunded	1.38±0.05	17.99±1.45	1.38±0.18	7.67 ±0.15	36.18±2.16
6-year-unbunded	Upper	Un-bunded	1.35±0.06	17.50±1.34	1.62±0.31	7.47±0.12	36.37±1.01
14-year-bunded	Lower	Bunded	1.20±0.10	22.57±0.05	3.17±0.04	7.80±0.00	41.75±0.01
14-year-bunded	Middle	Bunded	1.24±0.03	20.59±0.05	2.41±0.05	7.70±0.00	41.05±0.01
14-year-bunded	Upper	Bunded	1.27±0.02	20.33±0.04	2.15±0.04	7.73±0.06	40.94±0.01
14-year-unbunded	Lower	Un-bunded	1.33±0.05	16.84±2.43	1.57±0.08	7.67±0.06	36.59±1.35
14-year-unbunded	Middle	Un-bunded	1.28±0.05	15.99±0.99	1.55±0.10	7.60±0.10	36.52±1.26
14-year-unbunded	Upper	Un-bunded	1.30±0.15	18.09±1.46	1.47±0.21	7.67±0.23	36.01±2.49
15-year-bunded	Lower	Bunded	1.10±0.01	28.32±0.51	2.28±0.04	7.87±0.12	41.02±0.02
15-year-bunded	Middle	Bunded	1.20±0.02	23.17±0.55	1.83±0.08	7.93±0.06	40.52±0.03
15-year-bunded	Upper	Bunded	1.23±0.04	19.88±0.76	1.47±0.05	8.0±0.00	39.78±0.23

15-year-unbunded	Lower	Un-bunded	1.26±0.04	17.85±2.10	0.98±0.63	7.70 ±0.10	37.40±2.71
15-year-unbunded	Middle	Un-bunded	1.30±0.03	16.52±1.85	1.30±0.25	7.57 ±0.06	36.62±1.18
15-year-unbunded	Upper	Un-bunded	1.33±0.05	16.35±1.40	1.29±0.21	7.53±0.15	35.15±2.01
25-year-bunded	Lower	Bunded	1.04±0.03	22.60±0.07	2.23±0.04	7.63±0.06	41.62±0.12
25-year-bunded	Middle	Bunded	1.20±0.05	21.23±1.08	1.78±0.05	7.73±0.06	40.30±0.17
25-year-bunded	Upper	Bunded	1.21±0.05	20.63±0.03	1.60±0.41	7.70±0.10	40.08±0.24
25-year-unbunded	Lower	Un-bunded	1.32±0.07	16.86±2.36	1.26±0.18	7.63±0.06	36.49±1.28
25-year-unbunded	Middle	Un-bunded	1.26±0.06	17.75±1.60	1.34±0.23	7.57±0.06	34.58±2.57
25-year-unbunded	Upper	Un-bunded	1.30±0.05	18.66±1.18	1.14±0.05	7.63±0.12	36.09±3.80

Note: BD is bulk density, MC is moisture content, OC is organic carbon, pH is soil reaction, and CEC is cation exchangeable capacity.

1.3. Effects of stone bund ages, slope positions, and conservation status on wheat yields

Wheat yields differed significantly ($p < 0.05$) across stone bund ages, with the highest average wheat yields recorded on croplands bunded for 15-year-olds and the lowest on the rest stone bund ages. After 15 years of treatment, croplands with stone bunds produced the highest yields, with a biomass of 3.80 tons per hectare and a straw yield of 2.20 tons per hectare, compared to adjacent croplands without any conservation measures. Similarly, after 25 years of treatment, croplands with stone bunds produced 3.64 tons of biomass and 2.15 tons of straw yields, whereas un-bunded croplands had the lowest yields of 2.07 tons of biomass and 1.18 tons of straw per hectare. This resulted in a 1.57-ton increase in biomass and a 0.97-ton increase in straw yields per hectare. On average, as compared to the bunded croplands, adjacent un-bunded croplands produced lower wheat yields. Slope positions also had a significant effect on crop yields, which decreased as the steepness of the slope increased. The result of the descriptive statistics showed t. hat wheat yield differed significantly across stone bund ages, slope positions, and conservation status (Table 3 and Fig. 2).

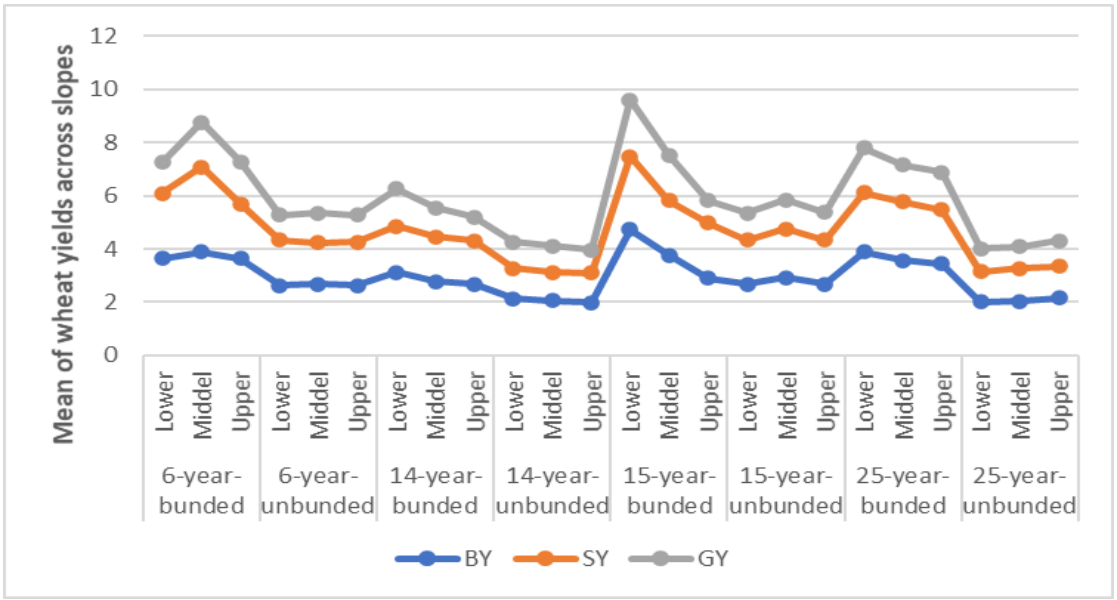

Figure 2. Biomass, straw, and grain yield distribution by slope position for bunded and unbunded cropland plots. Lower slopes show significantly higher wheat grain yields compared to middle and upper slopes, highlighting topographic influence on wheat biomass, straw, and grain yields.

1.4. Correlation matrix of soil properties and wheat yield

The bivariate correlation analysis revealed a strong positive relationship between soil CEC and both available P and pH, with correlation coefficients of r = 0.709 and r = 0.544, respectively, at a significance level of p = 0.01. These findings align with those by Hailu and Betemariyam [23], who also observed a positive correlation between CEC, available P, and pH. Additionally, CEC showed a strong positive correlation with OC and MC, with correlation values of r = 0.672, r = 0.632, and r = 0.771, respectively, at a p-value of 0.01. On the other hand, BD was negatively correlated with all soil properties and wheat yields, all significant at $p < 0.01$. These negative correlations may be attributed to the higher presence of OC and fine soil particles in the study area, as noted in previous research [25,39]. The highest and strongest positive correlation of wheat grain yield with soil OC, MC, N, and P, with correlation coefficients of r = 0.754, r = 0.728, r = 0.683, and r = 0.416, respectively, at a p-value of 0.01 was recorded (Table 3).

4. Discussion

The highest average Bd was found in the un-bunded cropland, while the lowest mean Bd was observed in croplands with stone bunds. This higher Bd in un-conserved land can be attributed to soil OM depletion caused by ongoing erosion, while the lower Bd in stone bund-treated plots is a result of reduced soil loss, erosion control, and the accumulation of OM from crop residues. This finding aligns with the research by Mohammed et al. [22], who reported lower Bd (1.00) in plots with physical SWC measures, compared to higher Bd (1.03) in un-conserved plots. Similarly, Reda et al. [40] and other studies [9,19,20,22,28] have shown that soil Bd varies between conserved and non-conserved plots, with lower Bd in conserved lands. As compared to the bunded croplands, adjacent un-bunded croplands produced lower wheat yields, as a result of lower soil fertility.

Table 2. Summary statistics (mean ± SD) of wheat biomass yield (BY), straw yield (SY), and grain yield (GY) across stone bund ages, slope positions, and conservation status (Bunded Vs Un-bunded)

Treatments	Slopes	Conservation status	BY (t/ha^{-1})	SY (t/ha^{-1})	GY (t/ha^{-1})
6-year-bunded	Lower	Bunded	3.63±0.04	2.45±0.03	1.18±0.05
6-year-bunded	Middle	Bunded	3.88±0.08	2.20±0.03	1.67±0.10
6-year-bunded	Upper	Bunded	3.64±0.10	2.06±0.08	1.58±0.07
6-year-unbunded	Lower	Un-bunded	2.64±0.08	1.69±0.12	0.95±0.15
6-year-unbunded	Middle	Un-bunded	2.67±0.11	1.57±0.12	1.10±0.02
6-year-unbunded	Upper	Un-bunded	2.64±0.09	1.61±0.15	1.03±0.15
14-year-bunded	Lower	Bunded	3.13±0.09	1.72±0.12	1.41±0.06
14-year-bunded	Middle	Bunded	2.77±0.09	1.68±0.06	1.09±0.15
14-year-bunded	Upper	Bunded	2.67±0.13	1.63±0.05	0.91±0.29
14-year-unbunded	Lower	Un-bunded	2.13±0.04	1.14±0.04	0.99±0.05
14-year-unbunded	Middle	Un-bunded	2.05±0.29	1.08 ±0.06	0.98±0.22
14-year-unbunded	Upper	Un-bunded	1.99±0.14	1.12±0.11	0.86±0.04
15-year-bunded	Lower	Bunded	4.73±0.03	2.75±0.16	2.12±0.40
15-year-bunded	Middle	Bunded	3.76±0.05	2.07±0.03	1.69±0.06
15-year-bunded	Upper	Bunded	2.91±0.13	2.07±0.05	0.84±0.17
15-year-unbunded	Lower	Un-bunded	2.67±0.12	1.66±0.10	1.01±0.06
15-year-unbunded	Middle	Un-bunded	2.92±0.02	1.83±0.03	1.09±0.02
15-year-unbunded	Upper	Un-bunded	2.69±0.14	1.65±0.11	1.04±0.11
25-year-bunded	Lower	Bunded	3.90±0.07	2.22±0.09	1.68±0.09
25-year-bunded	Middle	Bunded	3.58±0.06	2.19±0.03	1.39±0.04
25-year-bunded	Upper	Bunded	3.44±0.11	2.04±0.07	1.40±0.05

25-year-unbunded	Lower	Un-bunded	2.01±0.14	1.13±0.02	0.88±0.13
25-year-unbunded	Middle	Un-bunded	2.04±0.25	1.22±0.09	0.82±0.24
25-year-unbunded	Upper	Un-bunded	2.16±0.08	1.18±0.03	0.98±0.06

Note: BY is biomass yield, SY is straw yield, and GY is grain yield of wheat

Wheat yield was decreased when one moved from the lower to the upper slopes. This trend may be linked to the soil's texture, as sediment deposition and nutrient leaching from higher slopes influence the distribution of moisture and organic content. The accumulated organic matter in lower slopes improved moisture retention, reduced soil compaction, and enhanced wheat yields. The highest variation of wheat yields was found in the bunded plots and the lower slope of the bund. This variation can be explained by the higher OC content and the bunds' role in slowing surface runoff and increasing water infiltration. Lower slopes tend to retain more moisture, benefiting from runoff from higher slopes, which enhances moisture availability, while increasing wheat yields. These findings are consistent with Retta et al. [45], who found higher moisture content (19.81%) at the lower slopes compared to the upper slopes (10.52%). Similarly, others [17,34] reported higher moisture content in the lower slopes of treated plots.

The higher pH in the conserved farmland may be attributed to the increased accumulation of cations and OM, a finding supported by researchers who linked higher pH to better OM content [17,42]. Similarly, studies [21,37] observed higher pH in treated lands due to the preservation of basic cations through soil conservation methods. However, in contrast, studies [9,28] reported no significant difference in soil pH between treated and untreated lands. The study found higher wheat yields in bunded croplands as a result of soil fertility improvement. Other studies [19,46,47] also found that SWC measures led to increased biomass yields by enhancing soil moisture retention and the availability of nutrients for crops. These bunds have been shown to improve soil OC, MC, P, and soil CEC, which are critical indicators of soil fertility that are strongly associated with higher wheat yields. These findings align with those [34,48], which also reported positive associations between crop yield and SWC measures. In addition, Gebremedhin and YT [49] found higher grain and straw yields in the soil accumulation zone.

Table 3. Pearson's correlation coefficient matrix of the whole study site of soil properties and wheat yields in rain-fed croplands

	Bd	OC	MC	pH	TN	P	K	CEC	BY	SY
OC (%)	-.535**	1								
MC (%)	-.562**	.810**	1							
pH	-0.230	.551**	.524**	1						
TN (%)	-.464**	.959**	.763**	.568**	1					
Av. P g/kg^{-1}	-.716**	.432**	.633**	.278*	.384**	1				
K (cmol (+) kg^{-1}	-.303**	.540**	.593**	.322**	.515**	.308**	1			
CEC (cmol (+) kg^{-1}	-.636**	.658**	.771**	.544**	.627**	.709**	.404**	1		
Biomass yield	-.488**	.860**	.781**	.480**	.819**	.449**	.528**	.653**	1	
Straw yield	-.426**	.826**	.717**	.529**	.816**	.385**	.462**	.635**	.949**	1
Grain yield	-.434**	.754**	.728**	.340**	.683**	.416**	.501**	.527**	.883**	.700**

**, *. Correlation is significant at the 0.01 and 0.05 levels, respectively (2-tailed)

Slope positions also had a significant effect on soil and crop yields, which decreased as the steepness of the slope increased. The result of the descriptive statistics showed that soil and wheat yield differed significantly across stone bund ages, slope positions, and conservation status. Moving from a higher to a lower slope of the stone bund resulted in increased biomass and straw yields in the selected crop. This could be attributed to the better accumulation of nutrients in the finer soils at lower slope positions. This finding is consistent with the result by Haile et al. [50], who observed that both biomass and grain yields increased from the upper to the middle to the lower slope positions. The variation in wheat grain yields is likely due to differences in moisture

content and nutrient availability on the lower slopes, which promote better growth conditions. These findings align with those of Kravchenko and Bullock [51], who reported that topography and soil properties can account for up to 40% of crop yield variability, with yields varying between 10% and 78%.

5. Conclusions

Overall, the study concluded that croplands treated with stone bunds significantly reduced soil bulk density (Bd) and increased soil moisture, pH, total nitrogen (N), organic carbon (OC), potassium (K), available phosphorus (P), and cation exchange capacity (CEC) compared to the un-bunded croplands in the 0-30 cm soil depth. Notably, the 15-year-old stone bunds improved soil properties, particularly soil moisture (23.79%), OC (2.58%), N (0.22%), K (1.16 mg/kg^{-1}), and wheat grain yield compared to other stone bund ages. Also, the ANOVA results indicated that certain soil properties were significantly affected by the slope positions of the stone bunds, while others were not. Soil properties vary with slope position, with lower slopes showing better accumulation. The study concluded that stone bunds positively impact soil properties and wheat yields, although the effects on some soil nutrients vary with slope position. The increased soil OC, N, P, and CEC highlight the long-term benefits of stone bunds not only in restoring degraded lands but also in ensuring long-term agricultural output and resilience to climate change. These benefits offer valuable directions for policymakers and conservation planners to assess the effectiveness of stone bunds dynamically, and the study suggests that non-practicing farmers should aim at implementing stone bunds in the study areas and generally in regions facing severe land degradation, like northern Ethiopia to improve soil fertility, crop yield, and environmental sustainability.

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Silica Nanoparticle Based Nanohybrid Spheroids: Enhancing 3D Structural Stability and Adipogenic Potential

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Abstract: Three-dimensional (3D) culture systems, such as stem cell-derived spheroids, offer promising platforms for more physiologically relevant in vitro tissue models. However, these constructs often face limitations including core hypoxia and restricted nutrient diffusion, which impair cell viability and differentiation. In this study, we engineered adipose spheroids using human adipose-derived stem cells (hADSCs) integrated with mesoporous silica nanoparticles ($mSiO_2$) to enhance structural integrity and adipogenic function. $mSiO_2$ incorporation promoted spheroid compactness, reduced hypoxic stress, and improved metabolic activity over 14 days. Histological and gene expression analyses confirmed enhanced lipid accumulation and upregulation of adipogenic markers (PPARγ, adiponectin, FABP4) in the nanocomposite spheroids. This nanoengineered 3D model offers a biomimetic and stable platform for adipose tissue studies, providing an improved system for applications in metabolic disease modeling and regenerative research.

Keywords: Adipose spheroids, Mesoporous silica nanoparticles, Adipogenic differentiation

1. Introduction

Three-dimensional (3D) culture platforms such as spheroids offer a more physiologically relevant alternative to traditional two-dimensional (2D) systems by mimicking native tissue environments. Among various 3D systems, adipose spheroids derived from human adipose-derived stem cells (hADSCs) hold particular value for metabolic and regenerative studies due to the physiological relevance of adipose tissue. However, a major limitation of conventional spheroids is the formation of hypoxic, nutrient-deprived cores, which often result in cell death and poor reproducibility [1-5].

To address this challenge, we incorporated mesoporous silica nanoparticles ($mSiO_2$) into hADSC spheroids to improve internal mass transport, enhance cell viability, and promote uniform adipogenic differentiation. Mesoporous silica materials are known for their high surface area, biocompatibility, and tunable porosity, making them promising candidates for bioengineering applications. In this study, we developed a nanoengineered 3D adipose tissue model and evaluated its structural, metabolic, and adipogenic properties over an extended culture period.

2. Materials and Methods

2.1. Synthesis of Mesoporous Silica Nanoparticles

$mSiO_2$ nanoparticles were synthesized via a surfactant-assisted sol-gel process using tetraethyl orthosilicate (TEOS) and CTAB, followed by template removal through sequential chemical treatments. The particles were characterized by SEM, dynamic light scattering (DLS), and zeta potential analysis.

2.2. Spheroid Formation and Culture

hADSCs were seeded with or without $mSiO_2$ into ultra-low attachment (ULA) plates to form spheroids. Spheroids were maintained in culture for up to 14 days, with medium exchanges every 2–3 days. Three conditions were tested: control (no particles), low (8.5 pg/cell), and high (17 pg/cell) nanoparticle concentrations.

2.3. Structural and Functional Evaluation

Spheroid morphology, diameter, and roundness were monitored by brightfield microscopy. Metabolic activity was measured via ATP luminescence assay. Hypoxia was evaluated using LOX-1 fluorescent probes. Histological assessments were performed using H&E and Hoechst staining.

2.4. Adipogenic Differentiation and Gene Expression

After 7 days of culture, adipogenic differentiation was induced using established chemical media. Lipid accumulation was assessed by Oil Red O staining, and adipogenic gene expression (PPARγ, adiponectin, FABP4) was measured by PCR.

3. Results

3.1. Nanoparticle Characterization and Structural Effects on Spheroids

Synthesized $mSiO_2$ nanoparticles showed uniform spherical morphology with an average diameter of ~80 nm and stable negative zeta potential (Figure 1(a)). Cytocompatibility was confirmed in hADSCs, with viability >95% across tested concentrations.

Nanoparticle-incorporated spheroids exhibited improved morphological stability, with significantly higher roundness and more consistent compaction over 14 days (Figure 1(b)). SEM and histology confirmed cohesive architecture and reduced signs of necrotic core formation, especially in the 8.5 pg/cell group.

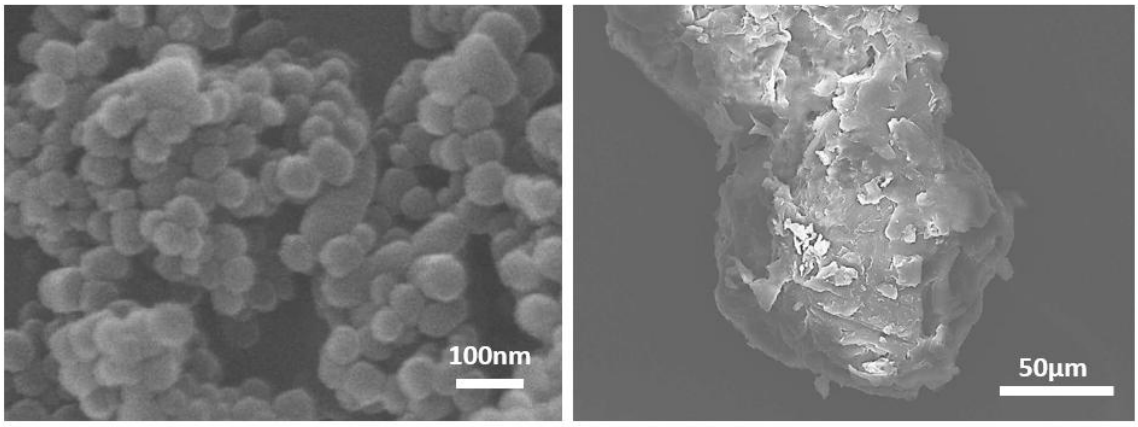

Figure 1. Scanning electron microscopy (SEM) images of the materials used in spheroid fabrication. (a) Mesoporous silica nanoparticles ($mSiO_2$) displaying uniform spherical morphology with rough surface texture (scale bar = 100 nm); (b) Representative nanoparticles integrated adipose spheroid showing a compact and cohesive outer structure after 7 days of culture (scale bar = 50 μm).

3.2. Metabolic and Hypoxic Response and Adipogenic Differentiation

Spheroids with $mSiO_2$ showed enhanced ATP levels and reduced hypoxia compared to controls. LOX-1 fluorescence was significantly lower in nanoparticles integrated spheroids, indicating improved intra-spheroidal oxygen and nutrient diffusion.

Oil Red O staining revealed more extensive and homogenous lipid accumulation in nanoparticles integrated spheroids (Figure 2(a)). PCR analysis showed upregulation of adipogenic markers in the 8.5 pg/cell group, supporting enhanced adipogenic commitment and maturation (Figure 2(b)).

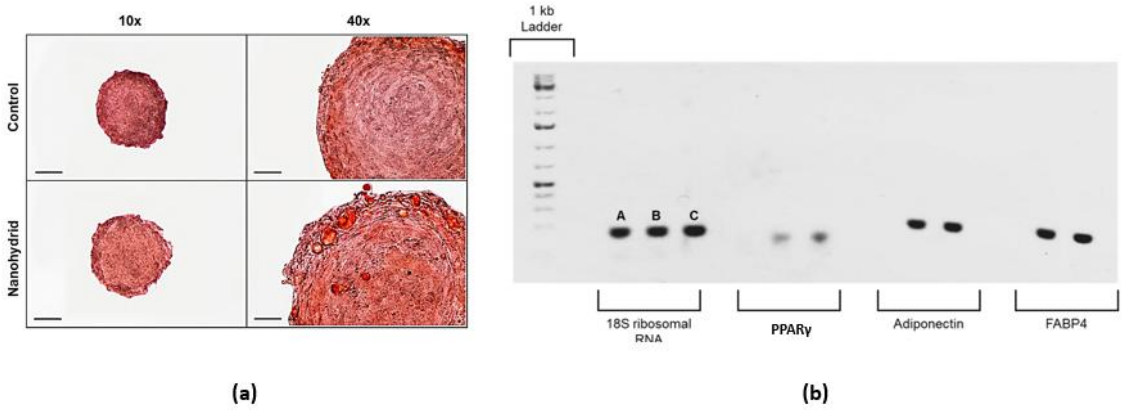

Figure 2. Evaluation of adipogenic differentiation in control and nanoparticle integrated hybrid spheroids. (a) Oil Red O staining at 10× and 40× magnification reveals enhanced lipid droplet formation in nanoparticles integrated spheroids, with more extensive and uniformly distributed lipid accumulation compared to controls (scale bars = 100 μm for 10×, 25 μm for 40×); (b) PCR analysis of adipogenic markers showing elevated expression of PPARγ, adiponectin, and FABP4 in nanoparticles integrated spheroids; 18S ribosomal RNA was used as the housekeeping gene.

4. Discussion

The incorporation of $mSiO_2$ into adipose spheroids improved both their structural robustness and functional outcomes. By enhancing oxygen/nutrient availability and mechanical support, these nanoparticles mitigated typical 3D culture limitations such as central necrosis and inconsistent differentiation. Enhanced expression of adipocyte-specific genes and uniform lipid distribution confirm the potential of this nanocomposite platform to serve as a more biomimetic model for adipose tissue studies.

5. Conclusions

We established a stable, functionally enhanced 3D adipose tissue model by embedding mesoporous silica nanoparticles into hADSC spheroids. This strategy offers a practical solution to overcome diffusion-related limitations in traditional spheroid models and enables more physiologically relevant adipogenic outcomes.

Author Contributions: Conceptualization, L.H.; methodology, R.L. and S.Y.H.; formal analysis, R.L. and S.Y.H.; investigation, R.L.; writing—original draft preparation, R.L.; writing—review and editing, L.H.; supervision, L.H.; funding acquisition, L.H.

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Conflicts of Interest: The authors declare no conflict of interest.

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Emodin Suppresses Proliferation and Stemness of Colorectal Cancer Cells via Induction of Apoptosis and Cell Cycle Arrest

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Abstract: Colorectal cancer (CRC) is the third most commonly diagnosed cancer worldwide and a leading cause of cancer-related deaths. Its progression and resistance to treatment are largely attributed to a subpopulation of cancer stem cells (CSCs), which play critical roles in tumor recurrence and metastasis. Emodin, a naturally occurring anthraquinone, has demonstrated anticancer potential in several malignancies. This study aimed to investigate the effects of emodin on CRC cell lines (HCT116 and SW480) and their stem-like populations. Luminescence-based viability assays showed IC_{50} values of 14.58 μM for HCT116 and 15.92 μM for SW480. Cell cycle analysis revealed G0/G1 phase arrest at increasing concentrations, while apoptosis assays confirmed enhanced apoptotic cell death, especially at higher doses. Furthermore, emodin increased mitochondrial ROS levels and decreased mitochondrial membrane potential (MMP) in both cell lines. These findings suggest that emodin not only inhibits proliferation but also targets CSC characteristics in CRC, highlighting its potential as a promising therapeutic agent.

Keywords: colorectal cancer; emodin; apoptosis; cancer stemness

1. Introduction

Colorectal cancer (CRC) is the third most frequently diagnosed cancer and the second leading cause of cancer-related death globally. CRC is characterized by a slow progression rate from benign polyps to malignant tumors. Since many patients present with the disease at an advanced stage, therapeutic options are limited and less effective [1].

Natural compounds have garnered significant interest for their ability to target multiple pathways simultaneously. Emodin is a natural anthraquinone derivative found in plants like *Rheum palmatum* and *Aloe vera*, known for its anti-oxidant, anti-inflammatory, and anticancer properties [2]. In previous studies, it has been reported that emodin inhibits tumor cell proliferation, promotes apoptosis, and suppresses tumor progression through multiple mechanistic pathways such as PI3K/AKT/mTOR and Wnt/β-catenin [3, 4].

A defining feature of CSCs is their ability to bypass normal cell cycle regulation, driving ongoing proliferation and escape from checkpoint-mediated arrest. Therapeutic agents that induce G0/G1 arrest or inhibit S phase entry have exhibited potential to eliminate CSCs [5, 6]. In parallel, apoptosis is a kind of programmed cell death crucial for ensuring cellular balance and eliminating abnormal cells. In cancer, the evasion of apoptosis is a hallmark that promotes tumor survival and progression [7]. Another distinctive characteristic of CSCs is their expression of stemness markers, including surface proteins, such as CD44, CD133, and ALDH1, as well as transcription factors, including Sox2, Nanog, and Oct4 [8]. These molecules, not only maintain stem-like phenotypes, but also regulate pluripotency, drug resistance, and the metastatic potential of CSCs. Therefore, modulation of these markers is an important goal in therapy targeted toward CSCs.

Emodin has become a potentially useful compound in modulating important mechanisms in cancer stem cell (CSC) biology. While some preliminary evidence does exist for emodin's anticancer activity, its specific effects on cell cycle regulation, apoptosis, stemness, and important signaling pathways in colorectal CSCs are still not elucidated. This study aims to investigate the therapeutic potential of emodin for targeting colorectal CSCs, and explore its effects on apoptosis and related molecular mechanisms.

2. Materials and Methods

2.1. Colorectal Cancer Stem Cell Culture

Human colorectal cancer cell lines HCT116 and SW480 were purchased from Korean Cell Line Bank (Korea, Republic of Korea). The cells were grown in DMEM supplemented with 10% fetal bovine serum (FBS) (R&D Systems, Minneapolis, MN, USA) and 1% antibiotic/antimycotic solution (Lonza, Walkersville, MD, USA), and subcultured using trypsin. To propagate stem-like tumorsphere cells, HCT116 and SW480 cells were cultured in DMEM/F-12 containing 1 × B-27, 5 μg/mL heparin, 2 mM L-glutamine, 20 ng/mL EGF, 20 ng/mL bFGF, and 1% penicillin/streptomycin. Cultures were kept at 37°C in a controlled humidity incubator (Thermo Fisher Scientific, Vantaa, Finland) under a 5% CO_2 atmosphere.

2.2. Cell Proliferation Assay

Cell proliferation was determined using the CellTiter-Glo® luminescence assay (Promega, Madison, WI, USA). HCT116 and SW480-derived CSCs were seeded in 96-white well plate (3 x 10^4 cells/well) and treated with different concentrations of emodin. After incubation at 37°C for 5 days, 20 μL of substrate solution was added to each well. The luminescence signal was detected using microplate reader (BioTek, Inc.,Winooski, VT, USA). The IC_{50} values from obtained data were analyzed using the curve-fitting program GraphPad Prism 5 (GraphPad Software, La Jolla, CA, USA).

2.3. Cell Cycle and apoptosis Analysis

HCT116 and SW480-derived CSCs cells (2 x 10^5 cells/well) were seeded in 60-mm cell culture dish, and treated with emodin (10, 20, and 40 μM). After 72 h of incubation, the cells were collected and stained with the cell cycle reagent and Muse® Annexin V & Dead Cell reagent, respectively. Then kept in dark place at room temperature for 20 min. The cell cycle and apoptosis analysis were performed using the Muse® Cell Analyzer MuseSoft_V1.8.0.3; Luminex (Austin, TX, USA).

2.4. DAPI assay

HCT116 and SW480-derived CSCs cells were seeded at a density of 5 x 10^4 cells/well in 24-well plate and exposed to emodin (10, 20, and 40 μM) for 24 h. Thereafter, the cells were stained with 20μg/mL of DAPI and incubated for 30min. Stained nuclei were visualized using the Optinity KI-2000F fluorescence microscope (Korea Lab Tech, SeongNam, Republic of Korea).

2.5. MitoSOX and MMP assay

HCT116 and SW480-derived CSCs cells were seeded at a density of 2 x 10^4 cells/well in 96-well plate and exposed to emodin (10, 20, and 40 μM) for 24 h. For mitochondrial ROS detection, the cells were stained with 1 μM of mitoSOX for 30 min. For mitochondrial membrane potential, cells were stained with TMRE (100 nM) for 30 min. The fluorescence signal was detected using microplate reader (BioTek, Inc.,Winooski, VT, USA).

2.6. Western blot analysis

HCT116 and SW480-derived CSC cells were plated in a 100-mm cell culture dish and exposed to emodin (10, 20, and 40 μM) for 24 h, then lysed with RIPA buffer. The samples were separated by 7.5-15% SDS-PAGE and transferred to PVDF membranes, and blocked for 1 h with 1-5% skim milk. Membranes were incubated with specific primary antibodies (dilution 1:2000–1:10,000) overnight at 4°C, followed by HRP-conjugated secondary antibodies (dilution 1:3,000) for 1 h at room temperature. Bands wew visualized using ECL and analyzed using ImageJ 1.5 software (NIH, Bethesda, MD, USA).

3. Results

3.1. Effect of emodin on the viability of colorectal cancer stem cells

Since the aim of this study was to investigate the effect of emodin on stem-like cells derived from HCT116 and SW480, the anti-proliferative impact on these cells was investigated using luminescence assay. According to the

results, the IC_{50} values were 14.58 and 15.92 μM, indicating that emodin exerts a stronger growth inhibitory effect on colorectal stem-like cells (Figure 1). These results suggest the ability of emodin to suppress CSC proliferation, notably.

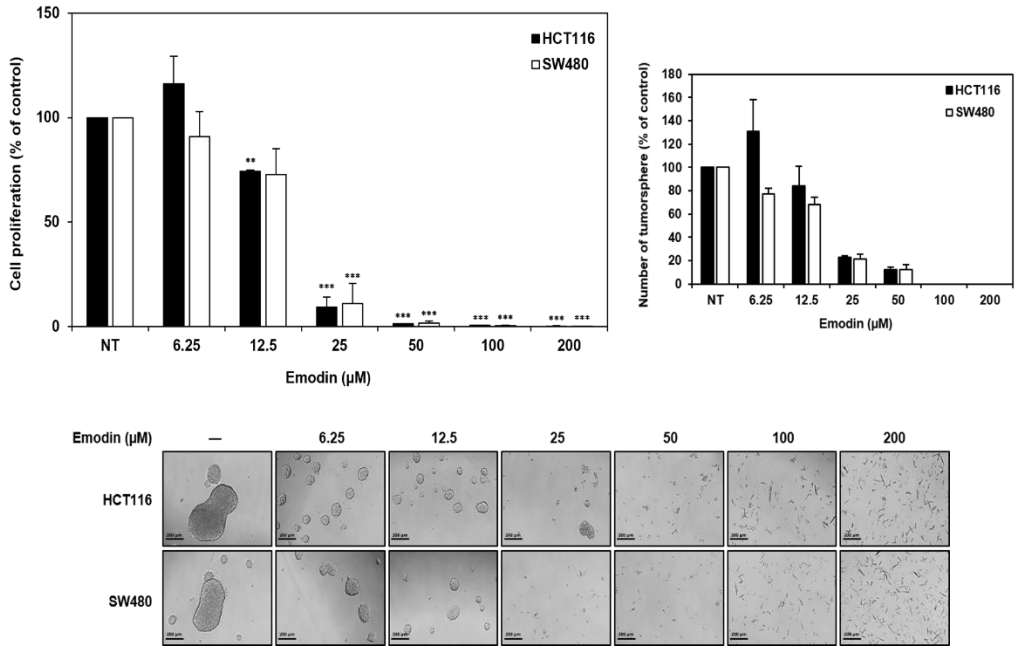
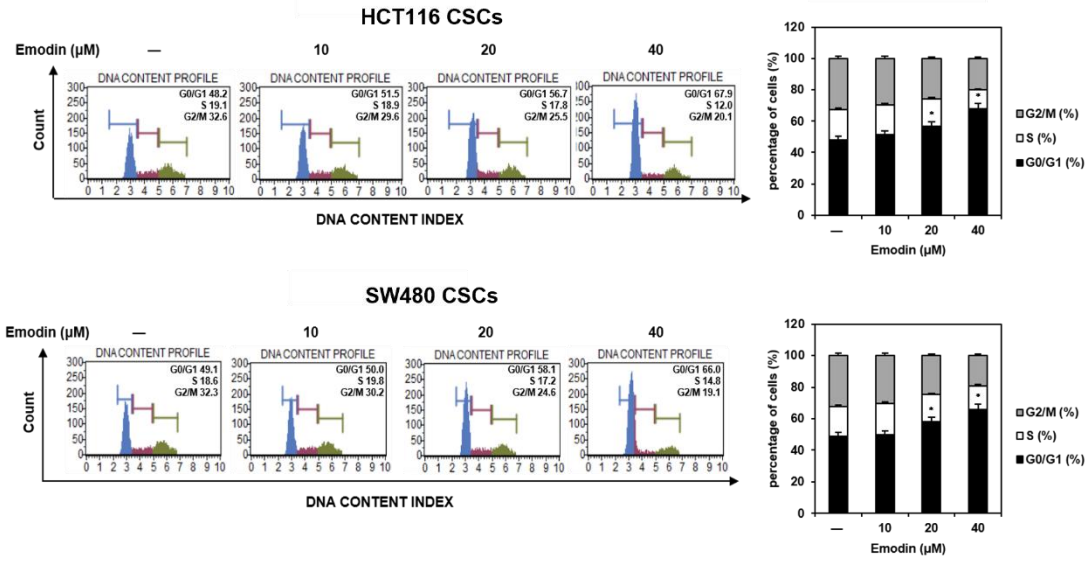


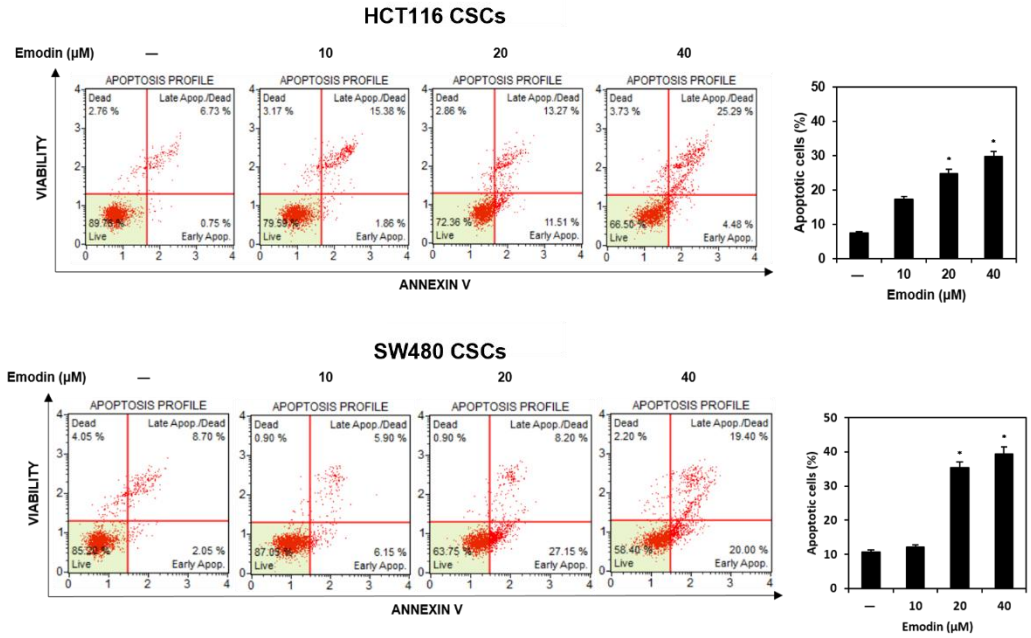
Figure 1. Effect of emodin on the proliferation and self-renewal capacity of HCT116 and SW4810-derived CSCs. The cells were treated with various concentrations of emodin (0-200 μM) for 5 days, and cell viability was assessed using a luminescence assay. ** $p < 0.01$, *** $p < 0.001$ vs. control.

3.2. Emodin induced cell cycle arrest and apoptosis in colorectal cancer stem cells

To investigate whether the antiproliferative effect of emodin is modulated by cell cycle arrest and inducing apoptosis, cell cycle distribution was initially analyzed using flow cytometry. The HCT116 and SW480-derived CSCs were treated with emodin (10, 20, and 40 μM), and as shown in Figure 2A, the population of cells increased at the G0/G1 phase in a dose-dependent manner. These results indicate that emodin inhibited colorectal cancer stem cells' proliferation by inducing cell cycle arrest at the G0/G1 phase.



(a)



(b)

Figure 2. Effect of emodin on the cell cycle distribution and apoptosis in HCT116 and SW480-derived CSCs. (a), (b) The cells were treated with the indicated concentrations of emodin and incubated for 72 h. Cell cycle distribution and apoptosis were detected using flow cytometry, and stained with the Muse® Cell Cycle Kit and Muse® Annexin V & Dead Cell Kit, respectively. * $p < 0.05$ vs. control.

To further verify whether emodin inhibits cell proliferation by inducing apoptosis, the HCT116 and SW480-derived CSCs were measured using flow cytometry. In Figure 2B, compared to the control group and the emodin (10, 20, and 40 μM) treatment group, the early apoptosis increased at high concentration. Thus, these results indicate that the anti-proliferative effect of emodin on HCT116 and SW480-derived CSCs is associated with cell cycle arrest at the G0/G1 phase and induction of apoptosis.

3.3. Emodin induced apoptosis-related cellular changes in colorectal cells stem cells

To explore how emodin influenced apoptosis and mitochondrial function in colorectal cancer stem cells (CSCs), DAPI staining was conducted. Figure 3A demonstrates that treatment with emodin (10, 20, and 40 μM) led to noticeable nuclear fragmentation. To further quantify mitochondrial involvement in emodin-induced apoptosis, mitochondrial ROS production and mitochondrial membrane potential (MMP) were determined using mitoSOX and TMRE staining, respectively. Quantitative bar graphs show that emodin strongly enhanced mitochondrial ROS production and dose-dependent MMP reduction in both cell lines (Figure 3B, C).

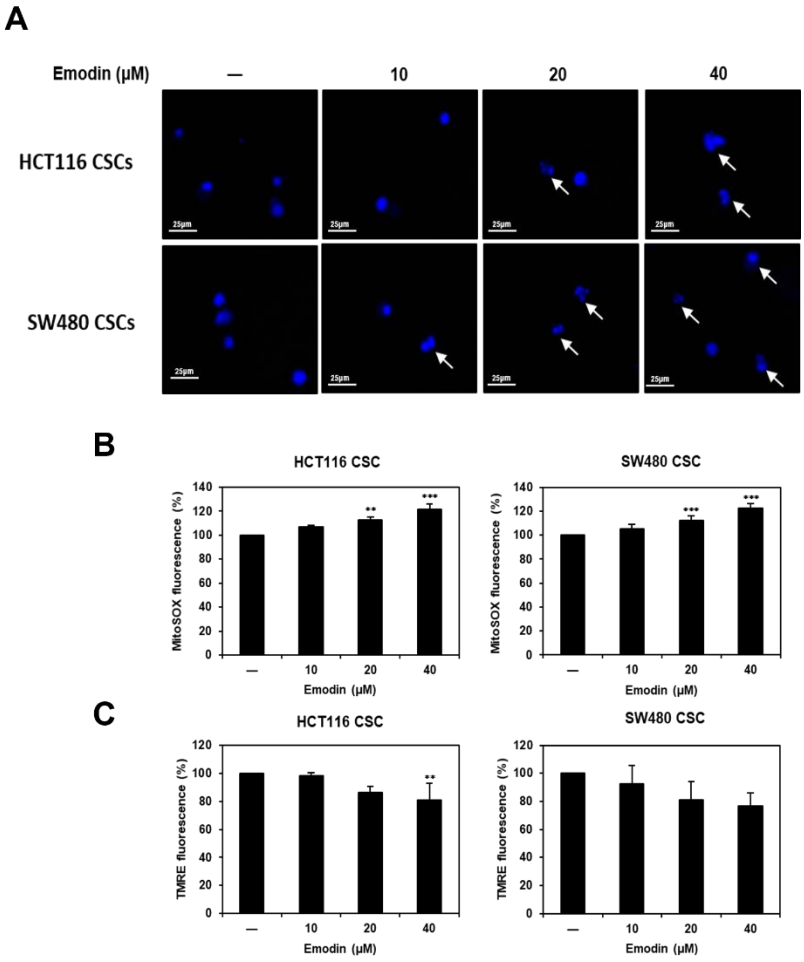


Figure 3. Evaluation of apoptosis-related cellular changes in HCT116 and SW480-derived CSCs. (A-C) The cells were treated with emodin (10, 20, and 40 μM) and incubated for 24 h: (A) The cells' nuclei were stained with DAPI, and nuclear fragmentation was observed using a fluorescence microscope; (B, C) The effect of emodin on mitochondrial ROS generation and MMP were assessed. The cells were stained with MitoSOX and TMRE, respectively. ** $p < 0.01$, *** $p < 0.001$ vs. control.

These results provide evidence to indicate that emodin induces apoptosis in colorectal CSCs, at least in part, through mitochondrial oxidative stress and disruption of mitochondrial membrane potential.

3.4. Emodin downregulates stemness markers in colorectal cancer stem cells

To assess the effect of emodin on the expression of colorectal cancer stem cell (CSCs) markers, western blot analysis was carried out on HCT116 and SW480CSCs after emodin treatment (10, 20, and 40 μM) for 24 h. As demonstrated in Figure 9, emodin treatment causes a dose-dependent inhibition in the expression level of the crucial CSC markers, including CD44, CD133, ALDH1A1, Sox2, Nanog, and Oct4, in both cell lines (Figure 5). Monitoring their expression helps evaluate how emodin influences CSC properties and potential therapeutic response.

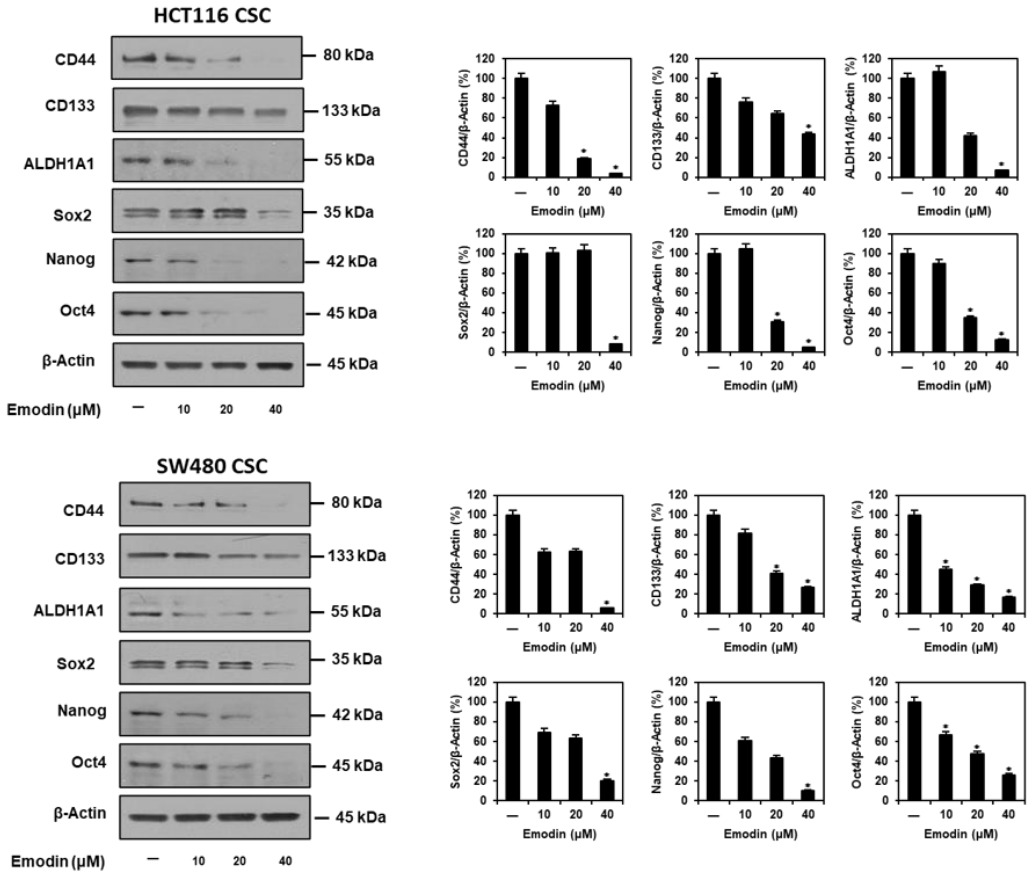


Figure 4. Effect of emodin on stemness markers in HCT116 and SW480-derived CSCs. The cells were exposed to emodin (10, 20, and 40 μM) and incubated for 24 h. protein levels were evaluated by western blot analysis. * $p < 0.05$ vs. control.

4. Discussion

Colorectal cancer (CRC) is one of the most frequently diagnosed malignancies globally, with high recurrence rates and limited long-term survival often linked to the persistence of colorectal cancer stem cells (CSCs). These CSCs exhibit self-renewal, tumor-initiating capacity, and resistance to conventional therapies, making them critical drivers of treatment failure and metastasis [9, 10]. In this study, emodin, a natural anthraquinone compound, exerts significant anti-CSC activity in CRC models through reducing stemness traits, inducing apoptosis, and inhibiting the cell cycle

As mentioned in previous results, emodin significantly inhibited tumorsphere formation and cell viability dose dependently. As well, emodin triggered great antiproliferative potency on CSCs. Furthermore, emodin caused downregulation of several key stemness markers indicate the observed reduction in self-renewal and tumorigenic ability.

Taken together, this study demonstrates that emodin effectively targets colorectal cancer stem cells (CSCs) by reducing stemness, inducing apoptosis, and arresting the cell cycle, and downregulates key CSC markers. Mitochondrial dysfunction and increased ROS further contribute to emodin-induced apoptosis. These findings suggest emodin as a promising candidate for CSC-targeted CRC therapy, warranting further in vivo validation. However, more studies are needed to confirm these effects *in vivo* and emodin's pharmacodynamics, bioavailability, and toxicity.

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Eco-friendly Biodegradation of PHB (Polyhydroxybutyrate) Using Newly Isolated Depolymerase-Producing Bacteria

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Abstract: This study focuses on isolating and characterizing novel polyhydroxybutyrate (PHB) depolymerase-producing bacteria for the efficient biodegradation of PHB. PHB, a promising biodegradable alternative to petroleum-based plastics, requires specific microbial enzymes for complete degradation. We identified *Janibacter terrae* from contaminated soil, demonstrating high PHB degradation efficiency via clear zone formation and enzymatic activity. Scanning electron microscopy (SEM) revealed increased surface roughness and porosity in degraded PHB films, while Fourier-transform infrared spectroscopy (FTIR) confirmed the cleavage of ester bonds, indicating enzymatic breakdown. The PHB depolymerase gene was successfully cloned and expressed in *E. coli*, yielding a functional 58 kDa enzyme. Optimal degradation conditions were 40°C, pH 8.0, and 96 h incubation, with 0.15% PHB concentration. Glucose and yeast extract enhanced enzyme activity, whereas heavy metals like Zn^{2+} and Co^{2+} slightly stimulated depolymerase production. These findings highlight *Janibacter terrae* as a potent PHB degrader, offering potential for sustainable plastic waste management. Further research on degradation metabolites and enzyme engineering could enhance industrial applications

Keywords: PHB (Polyhydroxybutyrate), Depolymerase, Biodegradation, *Janibacter terrae*

1. Introduction

Biopolymers are polymers derived from renewable resources such as plants, microorganisms, and agricultural waste. Unlike conventional plastics, they are biodegradable and compostable, offering a sustainable alternative to petroleum-based plastics [1]. Their use is growing in food packaging, textiles, construction, medical devices, and electronics due to increasing demand for eco-friendly materials [2]. Environmental issues, including the depletion of non-renewable resources, greenhouse gas emissions, inadequate recycling systems, and improper waste disposal, have heightened interest in biodegradable biopolymers like PHA and PHB [3]. These biopolymers can break down in specific biological environments, unlike synthetic polymers such as PP and PE [4].

Microorganisms utilize carbon from sugars, fatty acids, and other compounds to produce bioplastics, accumulating it intracellularly as PHA granules, with PHB being the most common form [5]. These granules are broken down into monomers by intracellular or extracellular enzymes, depending on their state. Intracellular PHA/PHB has a protein- phospholipid surface layer, degraded internally, while extracellular PHA/PHB, released after cell death, is degraded by external enzymes [6]. Extracellular PHB is partially crystalline, comprising 50–60% crystalline and 40–50% amorphous regions, and melts at 170–180 °C [4]. PHB has gained commercial interest for its unique properties. Semi-crystalline PHB granules are enzymatically degraded by PHB depolymerases identified in species like *Streptomyces ascomycinicus*, *Stenotrophomonas* sp. RZS7, *Streptomyces* sp. MG, and *Paucimonas lemoignei* [7–9]. Degradation rates vary from 21 hours to 4 months depending on the strain, environment, and polymer composition.

Despite its promise, PHB degradation faces challenges such as limited microbial specificity, incomplete breakdown, and nutrient limitations, especially phosphorus [10]. PHB-based products remain largely experimental. However, given the specificity and abundance of microorganisms in nature, microbial degradation remains one of the most effective strategies for complete PHB breakdown [6]. Emphasizing microbial degradation supports the development of bioplastics as a pollution-reducing, environmentally protective solution. This study

isolated novel PHB-degrading bacterial strains from contaminated soil, demonstrating their ability to use PHB as the sole carbon and energy source under various conditions. Chemical and thermal analysis confirmed significant biodegradation by the selected strains

2. Materials and Methods

2.1. Preparation of Emulsified PHB Medium, Films, and Degradation Assay

Bioplastic pellets (0.1 g) were dissolved in 20 mL dichloromethane (DCM) at 60 °C for 2 h. After dissolution, 1 mL of 2% Sarkosyl NL and distilled water were added, followed by 10 min sonication at 40% amplitude to form an opaque emulsion. The solvent was evaporated at 60 °C, and marine broth (MB) and agarose were added before autoclaving [11]. For film preparation, PHB pellets were dissolved in DCM (0.03 g/mL), cast onto glass, and air-dried at room temperature for 3 days [12]. Films were cut into 1.5 cm squares, sterilized with 70% ethanol and UV. For degradation screening, isolates were tested on minimal medium (MM) agar with 0.1% emulsified PHB. A 10 µL bacterial suspension was inoculated onto PHB plates, and clear zones were assessed after 2–3 days at 30 °C. For film degradation, 25 mg film pieces were autoclaved and incubated in 5 mL MB with *Janibacter terrae* at 30 °C, 200 rpm for 14 days. Residual films were washed, freeze-dried, and analyzed by SEM and GC.

2.2. Scanning electron microscopy (SEM)

To evaluate PHB film surface degradation, samples collected at 7, 14, and 21 days were centrifuged, washed with phosphate buffer (pH 6.0-7.0), and fixed in 2% glutaraldehyde overnight. After washing, the samples were dehydrated in an ethanol gradient (50%, 70%, 95%, 100%), sputter-coated with gold (5 mA, 120 s), and analyzed using a Hitachi TM4000Plus SEM at 5-15 kV [13].

2.3. Fourier transform infrared (FTIR) analysis of PHB

A Perkin-Elmer Spectrum One FTIR spectrometer (Perkin-Elmer Inc., WA, USA), equipped with a universal ATR sampling accessory and Perkin-Elmer software, was used to capture the spectra of dried PHB films to detect changes in the typical functional groups present in its structure. The spectral resolution was set at 4 cm^{-1}, and each spectrum was obtained by conducting 16 scans in the range of 3000-350 $cm^{-1.}$

2.4. Cloning and overexpression of PHB depolymerase

By using these primers, cloning and overexpression of the PHB depolymerase gene were performed with forward 5′-GAATTCATGCGTTCAGTGCGGTTG-3′, Tm=65.2°C, and reverse 5′-AAGCTTCGTCGGTGATGGCATTGT-3′, Tm=65.2°C. The amino acid sequence was deposited in the Gene Bank(HE577327.1) (https://www.ncbi.nlm.nih.gov/).

2.5. Biochemical characterization of PHB depolymerase enzyme assay

To determine PHB depolymerase activity of either crude or purified enzyme, a stable suspension of PHB in 50 mM Tris-HCl buffer solution (pH 7.0) was prepared by sonication at 20 kHz for 10 min [14]. The standard reaction mixture consisted of 0.9 mL of 50 mM Tris-HCl buffer (pH 8.0) and PHB powder (150 µg/mL). The reaction commenced with the addition of 0.1 mL of crude enzyme and was incubated for 20 min at 30°C. The reaction was halted by adding 0.1 N HCl solution to the mixture [15]. Enzyme activity was assessed by measuring the decrease in PHB turbidity using a spectrophotometer at 650 nm. One unit of PHB depolymerase activity was defined as the amount of enzyme needed to decrease the OD650 by 0.001 mL/min [8]. The effect of incubation temperature (15–55 °C) and pH (4.0–12.0) on enzyme activity was assessed over 96 h using PHB-containing MS media under standard assay conditions. To evaluate carbon and nitrogen source influence, PHB was replaced with various 0.1% carbon sources (glucose, fructose, lactose, mannitol, starch, sucrose), while nitrogen optimization involved substituting yeast extract with 0.01% inorganic (ammonium sulfate, nitrate, chloride) and organic (urea, peptone, tryptone) nitrogen sources. For substrate concentration, PHB was varied from 0.05% to 0.25% in the optimized medium and incubated for 192 h to determine the optimal conditions for enzyme production by Janibacter terrae. All activities were measured using standard assay protocols.

3. Results

3.1. Physical properties of PHB after biodegradation

After culturing *Janibacter terrae* on PHB-containing plates, clear zones formed, confirming its PHB-degrading ability. A time-dependent clear zone test on MB-PHB plates showed progressive expansion, with the zone of inhibition on the plate after 30 days, further verifying its robust degradation capacity. To assess surface erosion, a key indicator of biodegradation, PHB films prepared by solvent casting were incubated in a liquid MB medium. The residual films were collected at 7, 14, and 21 days to evaluate degradation (Figure 1).

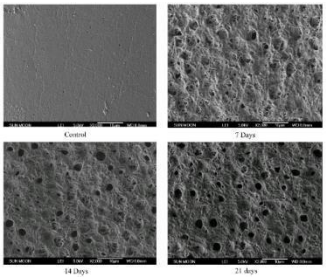


Figure 1. SEM observation

The surface of the degraded PHB film was observed using SEM with magnified images. Compared to the smooth surface of the control, the degraded films developed increasing roughness and porosity over time. Partial surface erosion was observed within the first 7 days, progressing to pronounced unevenness and large pore formation by day 21. In addition to the surface morphology, the functional groups in the degraded PHB films were analyzed using FTIR. Changes in several peaks were detected compared to the intact PHB film. For instance, the peak at 1917 cm^{-1} exhibited differences in the degraded PHB films, indicating that the C–H stretching bond underwent changes throughout biodegradation (Figure 2). Likewise, the intensity of peaks at wavenumbers of 925 cm^{-1} and 511 cm^{-1} considerably decreased during biodegradation, representing C–O stretching and C–H bending bonds, respectively [16]. In particular, the intensity of the peak at 925 cm^{-1} showed a significant reduction, indicating that the C=O ester bond was affected throughout biodegradation. This phenomenon may be attributed to the cleavage of PHB, a polymer composed of monomers connected by ester bonds. From the FTIR data, it was noted that *Janibacter terrae* impacted the PHB film during cultivation.

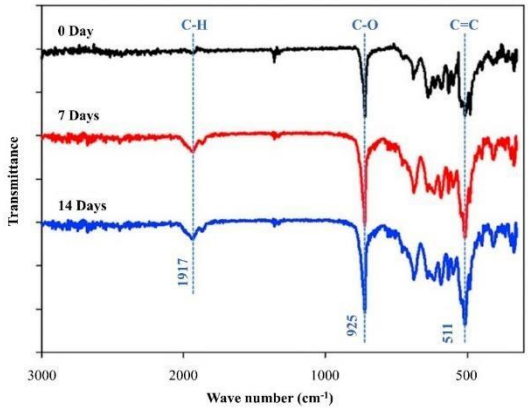


Figure 2. Changes in the physical and chemical properties of PHB film by microbial degradation. Functional group changes detected with Fourier-transform infrared spectroscopy (FT-IR).

3.1.1. Cloning and heterologous expression

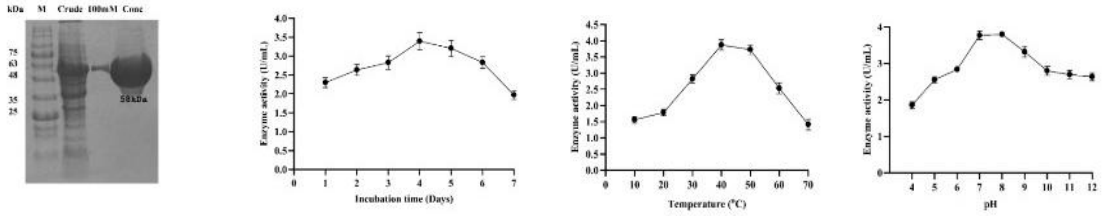
The gene encoding PHB depolymerase was cloned into the pET-32a (+) expression vector and expressed in *E. coli* BL21(DE3). His-tag was added to the N-terminus of the recombinant enzyme to facilitate purification. The soluble protein was purified by affinity chromatography. The soluble fractions and concentrated protein are shown in Figure 3(a). The recombinant PHB depolymerase had an estimated molecular mass of approximately 58 kDa, as

120 determined by SDS-PAGE, which corresponds to the value obtained by calculating the amino acid sequence of the 121 enzyme.

3.2. Optimization of PHB depolymerase

3.2.1. Effect of incubation time, temperature, and pH

The conversion of PHB (0.15% in the turbid medium) into its monomer/oligomer under the suitable growth conditions was found to be maximum (3.39 U/mL) with 4 days of incubation, as shown in Figure 3.



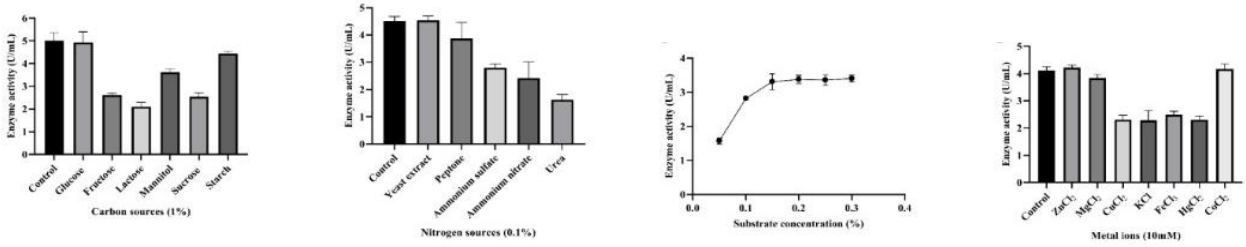
(a) **(b)** **(c)** **(d)**

Figure 3. (a) Optimization of PHB depolymerase production by *Janibacter terrae*; (b) Effect of incubation time; (c) Effect of incubation temperature; (d) Effect of pH.

PHB depolymerase production from *Janibacter* was optimized in the temperature range of 10°C–70°C with a 7-day incubation period. Maximum output of PHB depolymerase was achieved at 40°C (3.39 U/mL), after which a gradual decline (1.97 U/mL) in enzyme production was observed with an increase in temperature (Figure 3(b)). Among different pH ranges (4.0–12.0), maximum degrading activity was obtained at pH 8.0 (3.83 U/mL), as shown in Figure 3(c). Loss of degrading activity was observed by a sharp, steady decline in the pH range of (10.0–12.0), as shown in the graph

3.2.2. Effect of carbon, nitrogen sources, and substrate concentration

Among additional carbon sources, maximum hydrolytic activity was observed in the presence of Glucose (4.92 U/ 138 mL) after 96 h of incubation at 40°C, pH 8.0 as shown in Figure 4(a), while in the presence of Starch, Sucrose, Mannitol, Fructose, and Lactose, the PHB depolymerase activity was 4.44, 2.54, 3.62, 2.61, 2.11, and 2.98 U/mL, respectively. The presence of carbon sources other than PHB also affects or inhibits the PHB depolymerase production. The optimum output of PHB depolymerase was achieved with lactose, while in the current study, the best PHB depolymerase activity was observed with starch in addition to PHB.



(a) **(b)** **(c)** **(d)**

Figure 4. (a) Optimization of PHB depolymerase production by *Janibacter terrae:* Effect of Carbon sources; (b) Effect of nitrogen sources; (c) Effect of substrate concentration; (d) Effect of metal ions.

Among various organic and inorganic nitrogen sources, yeast extract exhibited the highest activity (4.53 U/mL), followed by peptone (3.87 U/mL), under optimized conditions of temperature (45°C) and pH (8.0) for 96 hours of incubation, as shown in Figure 4(b). Supplementation of ammonium sulfate (2.79 U/mL) and ammonium nitrate (2.42 U/mL) was found not to be significant for enzyme production, whereas urea proved to be a potent inhibitor for PHB depolymerase production, as activity went down to just 1.63 U/mL as compared to the control (4.15

U/mL), having PHB as a carbon source. It was observed that the activity of an enzyme is directly proportional to the concentration of PHB. Therefore, the best production (3.39 U/mL) was achieved at 0.15% of PHB in minimal media (Figure 4(c)). A higher or lower concentration markedly inhibits or reduces the activity of PHB depolymerase. Maximum production of PHB depolymerase was reported with 0.1% of substrate concentration from *Janibacter terrae* after 24 h of incubation.

3.2.3. Effect of metal ions on PHB depolymerase

The effect of monovalent (K^{+}), divalent (Mg^{+2}, Zn^{+2}, Cu^{2+}, Hg^{2+}, and Co^{2+}) and trivalent (Fe^{+3}) heavy metal ions on PHB depolymerase production was observed at 10 mM concentration under the optimized parameters of 40°C, pH 8.0, 0.1% starch, 0.01% yeast extract in enzyme production media for 96 h. The slightly enhanced activity was observed (Figure 4(d)) only with Zn^{+2} and Co^{+2} (4.22 U/mL) and (4.16 U/mL) as compared to control (4.11 U/mL) while Mg^{+2} 161 (3.84 U/mL) had no significant change while rest of the metal ions found as an inhibitor for production of the enzyme like Cu^{+2}, Fe^{+3} and Hg^{+2} showed 2.31 U/mL, 2.49 U/mL and 2.29 U/mL activity, respectively.

4. Conclusion

Janibacter terrae secretes an extracellular PHB depolymerase that induces significant surface erosion and chemical cleavage of PHB. Clear halos on PHB plates, along with increasing surface roughness and porosity (SEM), confirm time-dependent degradation. FTIR peak reductions near ~925 cm^{-1}, 511 cm^{-1}, and changes around 1917 cm^{-1} indicate ester bond cleavage and structural alterations during enzymatic depolymerization [17]. These findings suggest initial enzymatic attack on amorphous regions, leading to pore formation. Optimal enzyme activity occurred at 40 °C and pH 8.0 by day 4. This aligns with studies on Streptomyces lydicus MM10 [18] and Aspergillus fumigatus [19], supporting the thermotolerant nature of PHB degraders. Such traits are beneficial for composting and thermophilic processes.

Carbon and nitrogen sources influenced enzyme production: glucose and starch enhanced activity, while yeast extract outperformed inorganic nitrogen. Urea inhibited activity, suggesting enzyme repression or instability. Activity increased with PHB concentration up to 0.15%, declining thereafter—likely due to turbidity or feedback inhibition.

Metal ion tests showed mild activation by Zn^{2+}/Co^{2+}, neutrality by Mg^{2+}, and inhibition by Cu^{2+}, Fe^{3+}, and Hg^{2+}, reflecting metal–enzyme interactions. Heterologous expression produced a ~58 kDa His-tagged enzyme, confirming correct cloning and solubility. Overall, J. terrae and its depolymerase exhibit favorable traits for PHB degradation, warranting further kinetic, structural, and product-level studies.

5. Conclusions

With growing interest in eco-friendly alternatives to petroleum-based plastics, PHB has emerged as a key bioplastic. This study identified *Janibacter terrae* as an efficient PHB-degrading bacterium. Clear zone format ion, SEM analysis showing surface erosion, and FTIR-confirmed ester bond cleavage support its biodegradation ability. Molecular studies confirmed the successful expression of a 58 kDa extracellular depolymerase in *E. coli*, with optimal activity at 40°C, pH 8.0, over 96 hours using 0.15% PHB. These findings highlight the industrial potential of *J. terrae* and its thermotolerant enzyme. Future work should focus on metabolite identification, degradation pathways, and enzyme engineering for sustainable bioplastic disposal

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Author Contributions: Gobinda Thapa: Conceptualization, formal analysis, investigation, methodology, and writing-original draft. Tae-Jin Oh: Conceptualization, funding acquisition, project administration, supervision, validation, and writing-review & editing.

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Data Availability Statement: Data is contained within the article.

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Biochemical characteristics and molecular docking of a GH18 chitinase from lichen associated *Bacillus* sp. NP_108

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Abstract: The gene encoding GH18 protein (WP_061577947.1) from lichen associated *Bacillus* sp.NP_108 was annotated from the CAZyme databases. Based on phylogenetic analysis and multiple sequence alignment, WP_061577947.1 was found to be the GH18 protein family. The gene (WP_061577947.1) was successfully cloned, overexpressed in *Escherichia coli* BL21 cells. WP_061577947.1 showed strong activity towards colloidal chitin and activity on β-1,4 galactose containing monomers however, there was no activity towards crystalline chitin and chitosan. Biochemical characterization revealed that the protein exhibited optimal activity at 50°C and a pH of 6.0. Molecular docking also highlighted the protein structure and key residue present in GH18 protein family. The catalytic activity of enzyme exhibited substrate assisted catalysis. These findings support the chitin degradation capability of *Bacillus* sp. NP_108 and highlight the biotechnological importance of GH18 enzyme towards production of chitooligomers.

Keywords: GH18 chitin hydrolase, Bacillus sp., chitooligomers, colloidal chitin

1. Introduction

The sustainable bioeconomy focuses on increasing the use of high-value renewable biomass resources [1]. Among these, chitin, the second most abundant natural polysaccharide after cellulose, is a rigid amino biopolymer composed of linear poly β-1,4-N-acetyl-D-glucosamine chains [2]. Because of its rigid structure and insoluble in water, chitin cannot degrade naturally. To ensure its sustainable use, efficient extraction, modification, and conversion into valuable products are imperative for its sustainable utilization. Researchers have explored various microorganisms and chitin degrading enzymes have been adopted for the degradation of chitin and production of chitin oligosaccharides [3]. Microbes and enzymes break down chitin into valuable chitooligomers (COS), which have antifungal, biocompatible, and biodegradable properties [4,5]. These are used in food, medicine (wound healing, vaccines, tissue engineering), agriculture, and energy harvesting [6-10]. However, current chemical-based chitin degradation harms the environment. With over 109 tons of chitin waste produced yearly, eco-friendly conversion into high-value products is essential to reduce pollution and health risks [11,12]. GH18 family are the enzymes that play a pivotal role in the degradation of chitin, a structural component found in the fungi cell wall and the exoskeletons of arthropods [13-15]. These chitinolytic enzymes are widely distributed across various microorganisms, including bacteria, fungi, viruses, and plants, and mammals [2,6,14]. Bacterial GH18 chitinases are classified into three subgroups (A, B, and C) based on sequence identity. This enzyme family represents an evolutionary ancient and functionally diverse group, showing diversified structural and hydrolytic properties [12,14,15]. Numerous bacterial species from soil and aquatic ecosystems, including *Paenibacillus, Serratia, Streptomyces, Pseudomonas, Alteromonas, Bacillus, Microspora, Flavobacterium, Vibrio*, and *Erwinia*—have been found to produce active chitinases [2,12,13,15]. Bacterial chitinases are mainly valuable due to their rapid induction, environmental adaptability, and enhanced thermal stability. These advantageous traits make bacterial-derived enzymes a prime focus for industrial and biotechnological applications.

The GH18 family is a major group of Carbohydrate-Active Enzymes (CAZymes) with over 20,000 members from different microorganisms, of which nearly 450 have been experimentally characterized (https://www.cazy.org). About 300 GH18 enzyme structures are available in the Protein Data Bank

(PDB), offering valuable insights into their structure-function relationships. These enzymes feature a (β/α)8 barrel catalytic domain, often coupled with a carbohydrate-binding module (CBM). Their catalytic mechanism involves a glutamic acid (E) residue acting as a proton donor. According to the CAZy database, GH18 enzymes specifically target the C-2 acetamido group of polysaccharides, with most characterized members originating from bacteria and archaea. GH18 enzymes are identified by conserved sequence motifs (SxGG and DxxDxDxE). Based on amino acid similarity, chitinases are classified into GH18 and GH19 families, with GH18 being the more extensively studied group [16].

In this study, GH18 hydrolase encoding genes (WP_061577947.1) isolated from *Bacillus* sp. Np_108 have been cloned, expressed and various polysaccharides and PNP (p-nitrophenyl phosphate) substrates also screened. The protein showed substrate personality towards colloidal chitin in case of polysaccharides and however, PNP substrates β-1,4-galactopyranose and N-acetyl, β-1,4-galactopyranose.

2. Materials and Methods

2.1. Chemical and substrates

Shrimp shell chitin, colloidal chitin, starch, chitosan, crystalline cellulose, carboxymethyl cellulose, xylan and carrageenan, fucoidan and (4NP-α-Gal (4-Nitrophenyl α-D-galactopyranoside), 4NP-β-Gal (4-Nitrophenyl β- D-galactopyranoside), 4NP-β-GalNAc (4-Nitrophenyl N-acetyl-β-D-galactosaminide), 4NP-α-Glc (4-Nitrophenyl α-D-glucopyranoside), 4NP-α-GlcNAc (4-Nitrophenyl N-acetyl-α-D-glucosaminide), 4NP-α-Man (4-Nitrophenyl α-D-mannopyranoside), 4NP-β-Glc (4-Nitrophenyl β- D-glucopyranoside), 4NP-β-GlcNAc (4-Nitrophenyl N-acetyl-β-D-glucosaminide), 4NP-β-Man (4-Nitrophenyl β- D-mannopyranoside) were purchased from Sigma-Aldrich (Korea). Isopropyl-1-thio-D-galactopyranoside (IPTG), ampicillin, was purchased from Duchefa Bohemie (Seoul, Korea). Restriction enzymes were purchased from Takara Clontech (Shiga, Japan). T4 DNA ligase, DNA polymerase, and dNTPs were procured from Takara Bio (Shiga, Japan). All the chemicals and reagents were purchased from local suppliers.

2.2. Cloning and purification of recombinant chitinase

The 693-amino acid gene WP_061577947.1 from *Bacillus* sp. Np_108 was amplified via PCR using BamHI/XhoI-tailed primers (forward primer 5′-GGATCCATGAAGAAAGCCGCTTCA-3′and reverse primer 5′-CTCGAGCATCTAACGGCCGTATAC-3′) cloned into the pMD20-T vector, and transformed into *Escherichia coli* (DH5α). Positive clones were selected via blue-white screening and sequenced (Macrogen, Korea). The gene was then subcloned into vector pET32a(+), introducing an N-terminal His6-144 tag, and transformed into DH5α for plasmid propagation. The construction was subsequently expressed in BL21(DE3) cells, cultured in LB medium (100 μg/mL ampicillin) at 37°C until OD 0.6 -0.8. Protein production was induced with 0.4 mM IPTG (25°C, 48 h). Cells were harvested, lysed via ultrasonication, and the soluble fraction was isolated by centrifugation. The His-tagged protein was purified using TALON resin with imidazole gradient elution (10–100 mM), analyzed by SDS-PAGE, and concentrated using 50-kDa centrifugal filters.

2.3. Colloidal chitin preparation and enzyme assay

Colloidal chitin was prepared using a modified version of the method [17]. Briefly, 2.0 g of chitin power was dissolved in 200 mL of concentrated hydrochloric acid (11.6 M). The mixture was stirred well and stored at 4°C for 1 h, and mixture put into 37°C for 20 min. Subsequently, distilled water was added to the mixture, and was incubated for an additional 24 h at 4°C. The precipitate was harvested by centrifugation at 3,500 rpm for 30 min and washed repeatedly with sterile distilled water until the pH reached 7.0. Finally, the precipitate was dissolved in sterile distilled water to a final concentration of 10 g/L. The resulting solution was stored at 4°C for further use.

2.4. Biochemical characterization

The determination of optimum temperature was carried out through a temperature range from 10 to 70°C in potassium phosphate buffer (pH7.0). For the optimal pH determination, the pH changed gradually from 4.0 to 10.0. The following buffer was chosen to carry out the reaction with WP_061577947.1: 10 mmol/L sodium acetate

buffer (pH4.0-6.0), 10 mmol/L potassium phosphate buffer (pH6.0-7.0) and Tris/HCl buffer (pH7.0-10.0). Similarly, the determination of thermal stability at different temperatures, the WP_061577947.1was incubated in buffer (pH7.0) without the colloidal chitin at different temperatures 20-50^{0}C. For the pH stability determination, pH ranges from 6.0- 9.0 were used.

To detect the effect of metal ions, chelator, and NaCl in enzyme activity, the purified WP_061577947.1 was assayed in PPB (pH6.0) under the optimum conditions. The final concentration of metal ions was 1.0 mM. Metal ions used in this study are Mn^{2+}, Mg^{2+}, Ni^{2+}, Cu^{2+}, Ca^{2+}, Co^{2+}, Fe^{3+}, Na^{+}, K^{+}, Zn^{2+} and ethylenediaminetetraacetic acid (EDTA). 5% NaCl and glycerol were used to check the stability of enzymes. All experiments were carried out in triplicate.

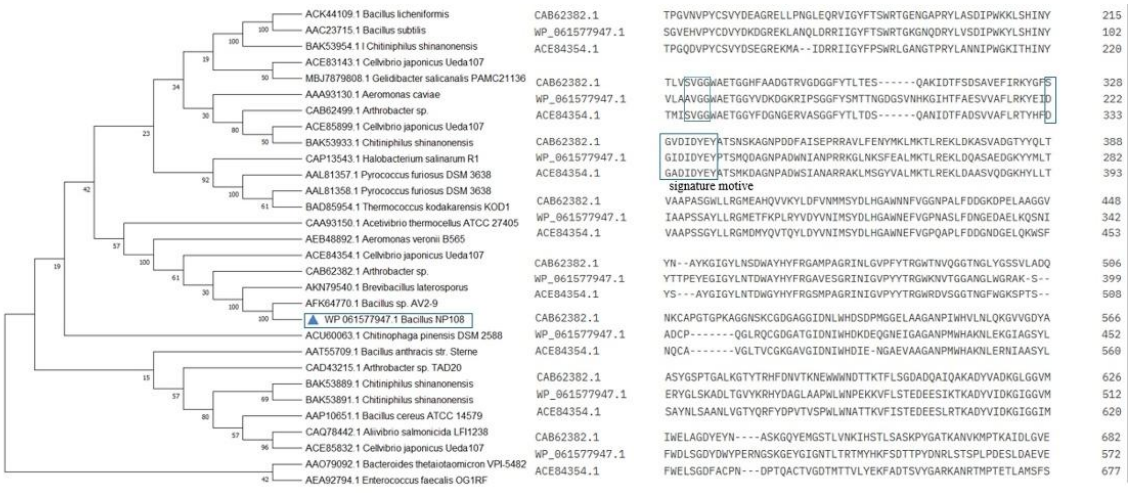
2.5. Homology modeling and molecular docking of GH18

The homology model of WP_061577947.1 was obtained from AlphaFold server after submitting the amino acid sequence. A protein (PDB;4txg) with the identity of 62.0% was taken as a reference template for structure prediction. 3D structure of tetra acetyl chitotretrose (N4) was taken as a substrate form the PubChem (https://pubchem.ncbi.nlm.nih.gov/). A molecular docking was carried out using Chimera 1.18 version coupled with AutoDock Vina [18]. A grid box, centered at X= -0.806, Y= -5.522, Z=1.753 A^o, was created covering the active site of protein. The grid box dimensions were 60× 60× 60 A^o. A binding affinity of -6.4 kcal/mol was obtained. The grid spacing was set to 0.503 A^o, and the docking search and exhaustiveness was 8. The resulting docking poses were observed using PyMOL (https://www.pymol.org).

3. Results

2.3. Bioinformatics analysis for GH18 chitinase

WP_061577947.1 protein from lichen associated *Bacillus* sp. Np_108 has been classified as GH18 hydrolase on CAZyme database. The phylogenetic position of WP_061577947.1 showed within the Cellvibrio *japanicus* Ueda107 clade. Further, multiple sequence alignment was performed with two closely related bacteria (Fig. 1A). GH18 chitin specific hydrolase usually contains conserve residue of DxxDxDxE and SXGG. WP_061577947.1 containing amino acids residues also showed same conserved residue as shown in Fig. 1B where, 229E residues responsible for the protonation glycosidic oxygen and -OH group present in the substrate assisted catalysis process.



(a) (b)

Figure 1. (a) The phylogenetic tree was constructed by the maximum likelihood method. The GH18 protein (WP_061577947.1) was found within the clade of bacillus species; **(b)** The multiple sequence alignment was done by using Clustal omega. The GH18 hydrolase active site motives were highlighted in the figure. Conserved sequence motif for GH18 hydrolase is DxxDxDxE and xVGG.

2.4. *Biochemical characterization of GH18 chitinase*

WP_061577947.1 was successfully overexpressed as a soluble protein, yielding 2.10 mg of purified protein from 400ml cells using Ni-affinity chromatography. The empirical molecular weight of the protein was determined to be 94.87kDa using SDS-PAGE (Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis) (Fig. 2).

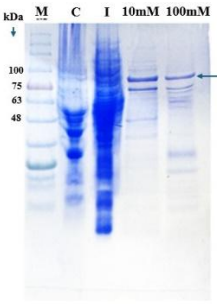
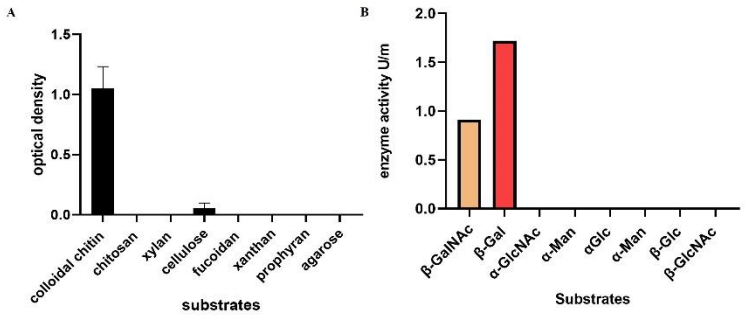


Figure 2. SDS-PASE of WP_061577947.1 from *Bacillus* species NP_108: The theoretical molecular weight of WP_061577947.1 is 94.78kDa. M; marker, C; crude, I; insoluble and 10mM and 100mM imidazole were used for the elution of protein.

At first, the purified protein was tested for its hydrolytic activity against various substrates, including shrimp shell chitin, colloidal chitin, starch, chitosan, crystalline cellulose, carboxymethyl cellulose, xylan and carrageenan, fucoidan.

No activity was detected with shrimp shell chitin, microcrystalline cellulose, caboxymethyl cellulose, and chitosan different degrees of deacetylation (75% and 90%), xylan, starch, curdlan, porphyran, carrageenan but the protein showed only activity towards colloidal chitin (Fig. 3A). For assessing the enzyme activity and biochemical properties of GH18 MBJ7879808.1, colloidal chitin was chosen as the substrate. Secondly, different PNP(p-nitrophenyl phosphate) substrates were screened (4NP-α-Gal (4-Nitrophenyl α-D-galactopyranoside), 4NP-β-Gal, 4NP-β-GalNAc, 4NP-α-Glc, 4NP-α-GlcNAc, 4NP-α-Man, 4NP-β-Glc, 4NP-β-GlcNAc, 4NP-β-Man. The GH18 chitinase showed activity towards only 4NP-β-Gal and 4NP-β-GalNAc. The higher activity was shown to 4NP-β-Gal (Fig. 3B).



(a) (b)

Figure 3. (a) screening of polysaccharides was done using DNS (Dintrosalicylic acid) method; **(b)** Screening of Para nitrophenyl substrates (PNP) was done. The release of PNP was measured at 405nm spectrophotometrically.

To find out the biochemical properties of enzyme, reaction of protein in different temperature and pH and its stability was done. GH18 WP_061577947.1 demonstrated an optimal temperature of 50°C, with 85% of its activity showed at 60°C and nearly 50% activity at 70°C (Fig. 4A). Interestingly, the enzyme can be regarded as a thermostable enzyme due to the optimum temperature of 50°C. Previously reported GH18 chitinase (MBJ7879808.1) isolated from Antarctic soil showed activity at 30°C [19]. The stability of enzymes showed almost all the enzyme activity was retained up to 4h at 50°C (Fig. 4C). At 40°C and 50°C, there was slight denaturation of protein takes place and more than 90% of activity was observed. Overall, the protein structure was not distorted at 50°C for 8h. Similarly, the optimum pH of the enzyme is at 6.0, which is slightly acidic (Fig. 4B). At

neutral pH, the activity of the enzyme was almost 95%. However, at alkaline pH and highly acidic pH, the activity was diminished. The stability of protein is limited. Only pH 6 and protein is table while alkaline pH, the stability of protein is lost (Fig. 4D).

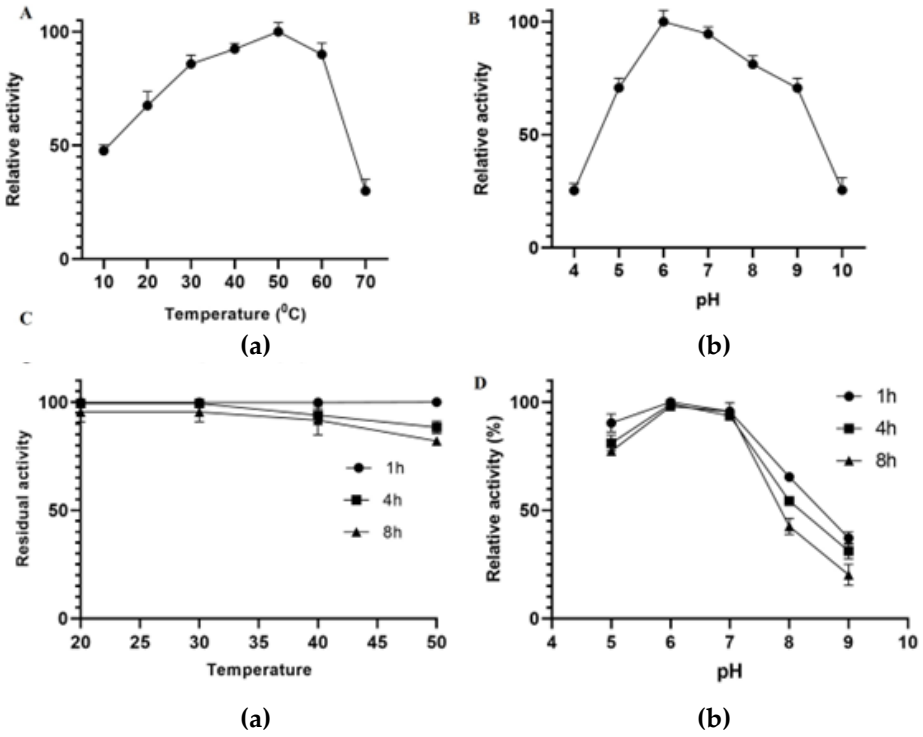


Figure 4. Biochemical parameter of GH18 WP_061577947.1. **(a)** indicates the optimum temperature; **(b)** shows optimum pH; **(c)** and **(d)** show the thermostability and pH stability of GH18 protein, respectively.

To check the role of metal ions, the enzyme was tested with chelating agents and osmotically active molecules. Three divalent ions Mg^{2+}, Mn^{2+}, and Ca^{2+} showed nearly 1.1-fold increase in the activity of enzyme (Fig. 5). However, the effect of Co^{2+}, Ag^{3+}, Ni^{2+}metal ions strong inhibition of enzyme activity. In the presence of Cu^{2+} , Co^{2}, K^{+}, Zn^{2+}, Na^{+}, and Fe^{3+} ions do not have any impact on enzyme activity. Glycerol and NaCl also have no influence on protein activity.

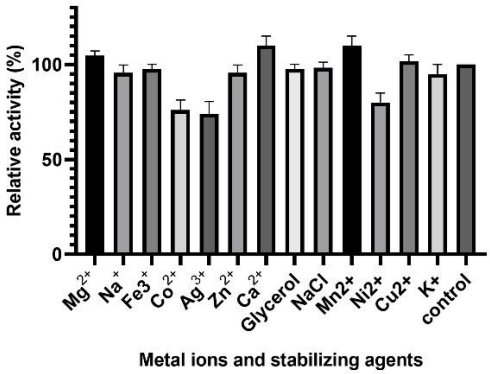
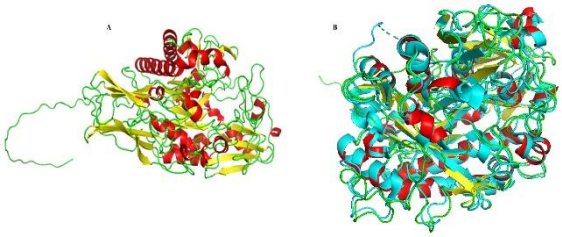


Figure 5. Effect of metal ions and stabilizing agent on enzyme activity.

3.2. In silico anaysis of GH18 (WP_061577947.1)

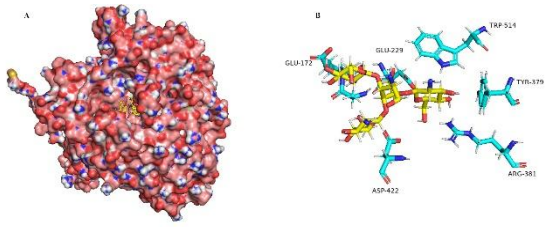
Homology modeling of chitinase was constructed using AphaFold server, a 0 e-value indicating its reliability and quality. The predicted structure was shown in Fig. 6A. The superimpose structure of our predicted structure with known structure PDB (4TXG) GH18 chitinase from *Chromobacterium violaceum* showed almost similar structure

as shown in Fig. 6B. The surface image of the predicted protein structure showed a semi-closed deep cleft observed on the surface of the protein where chitin easily bound (Fig. 7A). Structurally, GH18 chitinases consist of TIM barrel fold. The substrate assisted catalysis occurs in which the *229E* residues (WP_061577947.1) acts as a proton donor and -OH group present in in the substrate acts a nucleophile (Fig. 7B).



(a) **(b)**

Figure 6. (a) AlphaFold Server predicted structure of GH18 WP_061577947.1 with (β/α)8 barrel or TIM barrel; **(b)** Superimpose the predicted structure of GH18 WP_061577947.1 with GH18 Chitinase from *Chromobacterium violaceum (PDB 4TXG).*



(a) **(b)**

Figure 7. (a) Protein surface representation showed that the semi-close cleft was present deep inside the structure, the substrate assisted catalysis hydrolysis takes place; **(b)** Key catalytic residues and stabilizing residues. The *229E* residues deep inside the catalytic pocket of the protein involved as a proton donor and *422D* help to stabilize the structure. Similarly other residues were also present as a interacting residues.

4. Conclusion

To conclude, a GH18 family gene was identified, cloned from lichen associated *Bacillus* sp. Np_108 and finally expressed in *E.* coli BL21. The recombinant protein showed optimal activity at 50°C and pH 6.0 reflecting the thermostable activity of bacterial enzymes in acidic environments. Colloidal chitin utilization potential indicates that the bacteria use chitin as a source of energy for surviving in their habitat. Molecular docking and sequence alignment highlighted key conserved motif in GH18 hydrolase pivotal for chitinolytic activity . This result may support the chitin utilization potential of *Bacillus* sp. Np_108 strain.

Author Contributions: Conceptualization, Lakshan Paudel.; methodology, Lakshan Paudel.; software, Lakshan Paudel.; validation, Lakshan Paudel.; formal analysis, Lakshan Paudel.; investigation, Lakshan Paudel.; resources, Tae-Jin. Oh.; data curation, Lakshan Paudel, Sora Han.; writing—original draft preparation, Lakshan Paudel.; writing—review and editing, Tae-Jin. Oh.; visualization, Lakshan Paudel, Sora Han.; supervision, Tae-Jin. Oh.; project administration, Tae-Jin. Oh.; funding acquisition, Tae-Jin. Oh. All authors have read and agreed to the published version of the manuscript." Authorship must be limited to those who have contributed substantially to the work reported.

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CMOS LNA With IM_3 Cancellation Using Auxiliary Transistor Arrays for a 5G Applications

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Abstract: This paper presents a novel IM3 (third-order intermodulation) cancellation technique using a structured auxiliary transistor array, implemented in 180nm CMOS technology, to enhance the linearity of array amplifiers. The proposed technique applies a selective transistor-capacitor array with gate voltages and switchable branches for accurate amplitude and phase tuning of generated IM3 components. With a 180° phase difference and amplitude balance between the main and auxiliary path IM3 signals, the design improves the third-order intercept point (IIP3) performance to +11 dBm, at 1.0 to 1.1 GHz. while maintaining a gain of 22 dB. With low noise figures (NF) of 4.9 to 4.2 dB in the band. Measurement results demonstrate linearity enhancement across a wide bandwidth without high bias current or additional feedback loops. In addition, the reconfigurable nature of the auxiliary array provides flexibility to different operating conditions and frequency bands. Compared to conventional IM3 techniques, the proposed technique offers high flexibility, low power and scalability, Improved Linearity, Wideband Operation, phase compensation, gain tuning, reconfigurability, for future advanced wireless communication systems. Simulation and measurement results verify substantial IM3 suppression without degrading the amplifier core performance.

Keywords: IM3 cancellation, auxiliary path, 180nm CMOS, transistor array, linearization, array amplifier

1. Introduction

In modern RF front-end systems, particularly those used in 5G automotive and beamforming applications, the low-noise amplifier (LNA) serves a critical role in preserving signal fidelity while minimizing noise. While conventional LNA designs typically prioritize gain and noise figure (NF), linearity has become an equally essential parameter, especially in scenarios involving adjacent-channel interference or multi-tone signals. Third-order intermodulation distortion (IM_3), a consequence of nonlinearities in the amplification path, introduces in-band spectral artifacts that degrade the signal-to-noise ratio and overall receiver performance. The severity of this distortion is commonly quantified using the input third-order intercept point (IIP3), which reflects the amplifier's ability to handle large input signals without generating excessive nonlinearity. Previous works have attempted to mitigate this issue through post distortion techniques involving diode-connected or cascode auxiliary stages, or through feedback-based IM_3 suppression circuits [1-3]. While these methods can improve linearity, they often introduce trade-offs in terms of increased circuit complexity, degraded noise performance, or limited operational bandwidth [4, 5]. To address these limitations, this paper proposes a new CMOS LNA architecture that employs an auxiliary transistor array designed to generate a 180° phase-inverted IM_3 signal. This signal is injected directly into the output node to cancel the distortion created by the main amplification path. The method improves linearity while maintaining simplicity, offering several key advantages including enhanced IIP3 performance through direct IM_3 cancellation, the ability to scale area and power by adjusting the number of auxiliary devices, precise control over cancellation magnitude and phase, and fine tunability via gate voltages for stable operation under process, voltage, and temperature variations. The proposed LNA, implemented in 180 nm CMOS technology and operating in the 1–1.1 GHz band, demonstrates a +6 dB improvement in IIP3 with minimal degradation in gain and NF.

2. Circuit topology

The circuit architecture is composed of a primary common-source amplifier stage that performs the main signal amplification, and a parallel-connected auxiliary transistor array that serves to cancel third-order distortion

components. The auxiliary transistors are biased in the subthreshold region to reduce power consumption while injecting a third-order current component that is 180° out of phase with the IM_3 current generated by the main path. This cancellation occurs at the output summing node, where the main and auxiliary currents combine. The effectiveness of this technique depends on precise matching of the phase and magnitude of the IM_3 signals. The auxiliary array achieves this through careful sizing and analog gate voltage control, which allows for tuning under PVT variations [1, 3]. Unlike traditional feedback loops or switchable modes, the proposed design achieves continuous cancellation across the entire operating bandwidth without requiring digital reconfiguration or additional bias circuits [4, 5]. Furthermore, the intrinsic parasitic capacitances introduced by the auxiliary transistors at the output node beneficially shift the output impedance closer to 50 Ω, improving S22 from –11 dB to –16 dB and enhancing matching performance [1-2]. Though the array introduces a slight gain penalty due to current sharing and output loading, the structure ensures that this reduction is minimal and predictable. Importantly, if the auxiliary and main path currents are not precisely balanced, load symmetry can be disturbed, slightly affecting the return loss and S-parameter behavior. Nevertheless, the approach maintains a high degree of robustness, simplicity, and adaptability, making it suitable for next-generation CMOS RF front ends where area, power, and linearity must all be optimized simultaneously.

3. Simulation results

The LNA is implemented using 180 nm CMOS technology and simulated across the 1.0.

1.1. GHz range. Simulated S-parameters are shown in Fig. 2

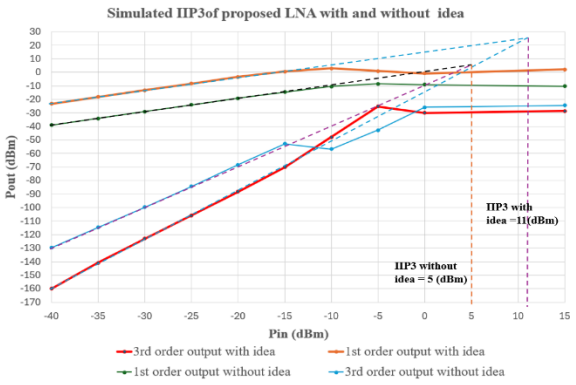

Figure 1. Simulated and Conventional IIP3.

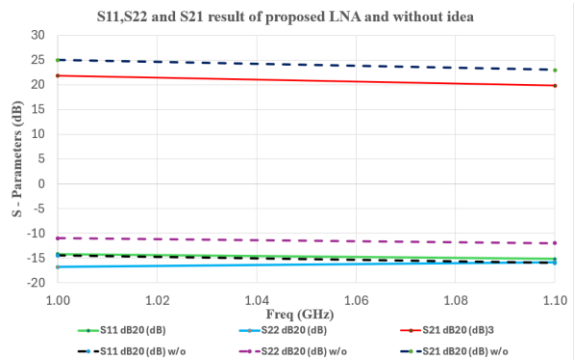

Figure 2. Simulated S-parameters(S11, S22, S21) of the proposed and Conventional design.

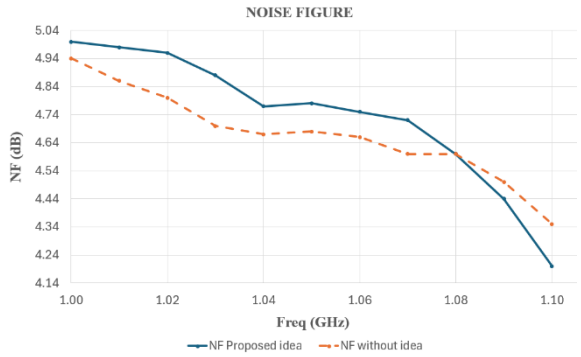

Figure 3. Simulated and Conventional NF.

The proposed LNA was designed and simulated using 180 nm CMOS technology across the frequency range of 1.0 to 1.1 GHz. The simulated S-parameters show that input return loss (S11) remains consistently below –10 dB, indicating good input matching throughout the operational band. With the auxiliary array deactivated, the output return loss (S22) measures around –11 dB, but improves to –16 dB when the array is enabled due to the added parasitic capacitance from the auxiliary transistors, which shifts the impedance closer to the desired 50 Ω value. The forward gain (S21) experiences a slight reduction from 25 dB to 22 dB when the auxiliary array is active, primarily due to the loading effect introduced by the auxiliary current path. Noise figure performance also shows improvement, with a reduction from 4.35 dB to 4.2 dB near 1.08 GHz, attributed to more favorable impedance matching and redistribution of current density that lowers noise contributions from the main path. The most significant performance gain is observed in linearity, where IIP3 improves from +5 dBm to +11 dBm with the auxiliary array enabled, confirming the effectiveness of the 180° phase-inverted IM_3 cancellation. The circuit achieves this linear improvement without requiring any feedback loops or switching stages, operating entirely in real-time with continuous cancellation. Despite these enhancements, total power consumption remains under 30 mW, demonstrating that the linearity gain does not come at the cost of power efficiency. Overall, the simulation results confirm that the proposed LNA structure provides robust performance with improved linearity, competitive noise figure, and strong impedance matching, all while maintaining a compact and scalable architecture suitable for 5G receiver front ends.

Table 1. Performance summer and comparison

Parameters	**This work**	**[1]**	**[2]**	**[3]**	**[4]**
Technology CMOS	**180nm**	**180nm**	**130nm**	**180nm**	**180nm**
3-db BW(GHz)	**1 - 1.1**	**6.2-13.4**	**6.8-11.2**	**9.9-13.5**	**0.048-1.2**
GAIN (dB)	**22**	**13.6**	**20.5**	**17.1**	**14**
P_{dc}(mW)	**28**	**297**	**100.8**	**28.8**	**34.8**
NF (dB)	**4.9 - 4.2**	**4.7**	**1.35**	**4.4-5.2**	**3**
IIP3 (dBm)	**11**	**9.5**	**5.25**	**2**	**3**
FOM (dB)	**16.78**	**5.38**	**19.65**	**12.13**	**2.22**

$$\mathbf{FOM = 10\log_{10}\frac{G_{lin}\,BWGHz\,.\,IIP3_{lin}}{(NF_{lin}-1).\,Pdc}}$$

4. Conclusion

This paper introduced a highly linear LNA using an auxiliary transistor array structure which is presented for 5G sub-GHz applications, with the core objective of delivering low noise and high linearity performance. A noise reduction inductor is used at the cascode stage to achieve lower noise performance. For high linearity performance, employing a novel auxiliary transistor array-based cancellation technique to suppress third-order intermodulation distortion (IM_3). By generating a 180° out-of-phase IM_3 signal and summing it at the output, the design achieves +6 dB IIP3 improvement with minimal impact on gain or noise. These attributes make it ideal for future automotive and beamforming applications in CMOS technologies.

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Evolution of the Planet Earth for Human Civilizations

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Abstract: The atmospheric CO_2 level has been mostly at the lowest level of 180-300 ppm over the last 420 thousand years before mankind started to burn woods and utilize fossil energy in a large scale and thus increase the atmospheric CO_2 level and temperature. Antarctica moved to the South Pole and started accumulating ice at around 35 million years ago to become the largest ice reservoir and a buffer to control the sea level by accumulating more ice at higher atmospheric temperatures. The Kikai-Akahoya eruption in 5250 BC forced Jomon people to migrate from the southwestern Japan to the northeastern Japan, Korean peninsula, Southeast Asian islands, and father into Eurasia. These events among others in the evolution of planet Earth appear to allow advanced human civilizations to spread and develop to higher levels. Especially, Jomon people could have reached as far as Middle East according to recent genetic studies and brought back Sumerian and Israeli cultures back to Japan. Preservation of such ancient cultures and genetic information may have become possible by people migrating to such isolated geographic locations as high mountains (Tibet) and islands (Japan). Changes in the climate and sea level of the planet Earth must have highly affected such migrations.

Keywords: planet, Earth, environment, CO2, civilization, Jomon, Israel, Japan

1. Introduction

Recently, major media and media-biased scholars keep emphasizing the threat of climate change to human civilization without sound knowledge of the facts and mechanism of the evolution of our planet Earth. When such major media deceives people, their democratic government may tend to fund research projects which are popular among its tax payers. Although academic researchers may be tempted to express their research results accepted by people and funded by the government, researchers must be based on only facts and reasoning free from any political or economic bias. Otherwise, they have no value, and brainwash people, causing bad influence to the society. In this paper, a big picture of the development of our planet Earth is reviewed, and its influence on human civilizations is addressed in a fair manner without any negative tone.

2. Evolution and Climate Changes of the Planet Earth

The Earth is the only habitable planet over a long period of time (billions of years) known to date in that not only its surface average temperature allows the presence of liquid water (which is often the definition of being "habitable" in astronomy), but also it has a large moon to stabilize the Earth's spin axis inclination [1] and slow down its spin speed (and wind speed), both a large amount of water (ocean area) and some lands, an adequate atmospheric condition for life and greenhouse effect, a liquid iron outer core generating a strong magnetic field to block solar wind, plate tectonics [2] to replenish important elements such as carbon to the surface, etc. In spite of its remarkable dynamical stability of the Earth, it evolved over its 4.6 billion years history even after its initial formation period, changing its surface condition and climate to some extent.

2.1. Astronomical cycles of solar forcing onto the Earth

Milankovitch cycles describes the intra-annual and latitudinal distribution of solar radiation onto the Earth's surface based on variations in the eccentricity, inclination, and precession of its elliptical orbit around the Sun, and the inclination and precession of its spin axis [3]. In addition, variations in the solar activity affect the amount of solar radiation and solar wind, changing the amounts of light (including heat) and magnetic field coming to the Earth. Schwabe cycle is a periodic 11-year change in the Sun's activity measured in terms of variations in the number of observed sunspots on the Sun's surface [3]. In addition, solar activity shows a longer cycle of about 100 years over the last 300 years, and it is currently in a low-activity era [4].

2.2. Earth surface evolution

In addition to the external heat input and internal activities of the Earth, its surface environment is affected by its atmospheric composition, water (including ice and vapor) distribution, and biological activities. Especially, microorganisms changed the initial CO_2 atmosphere by producing O_2 and reducing CO_2 [5]. CO_2 kept mostly decreasing over the phanerozoic eon of about 540 million years. We are currently in an ice age where the global mean surface temperature drops by 10-20 °C [6], and within this ice age we are in an interglacial period where the temperature is higher by about 8 °C. The last glacial period ended about 12 thousand years ago [7] when the atmospheric CO_2 level was at the lowest level of about 200 ppm.

3. Favorable Changes of the Earth for Human Civilizations

Through the above-mentioned changes of the Earth, certain favorable conditions were prepared changes occurred for humankind to emerge, survive, form civilizations, and develop science and technology. Such key changes are described below.

3.1. Timely movement of Antarctica as a time capsule

Thanks to plate tectonics, Antarctica moved to the South Pole and started accumulating ice at around 35 million years ago to become the largest ice reservoir and a buffer to control the sea level by accumulating more ice at higher atmospheric temperatures. In addition to this role of stabilizing the environment, Antarctic ice is like a time capsule which contains ancient water, air bubbles, microorganisms, interplanetary dusts, and meteorites, through which humankind can extract information on the past climate (such as temperature) and life, and the early composition and evolution of the Solar System. Remarkably, it moved to the right place (South Pole) and accumulated its ice and those precious materials in it in time for humankind to appear, develop science, visit Antarctica, and discover and utilize them for science. If humankind had not appeared until tens of millions years after the present time, the Antarctic might move away from the South Pole and lose them.

3.2. Decreased CO_2 level before human civilizations flourished

The atmospheric CO_2 level decreased to the bear minimum level of 180 ppm around 17,000-15,000 BC, nearly endangering the survival of plant life on the Earth. Then, human civilizations emerged and flourished by burning woods and utilizing fossil energy, thereby increasing CO_2 in the atmosphere to help plant life to grow, which in turn produces O_2 for animal life. The lucky coincidence of the evolutions of the Earth and biological species to humankind is analogous to the case of Antarctica moving to the South Pole at the right timing as described above.

3.3. Jomon Sea Advance to develop an ocean culture

The Earth's temperature changed drastically up and down over the period of 15,000-8,000 BC, ending up increasing by ~7 °C to today's temperature. Especially rapid warming by 7-8 °C could have occurred over just a few decades around 12,500 and 9,500 BC [8]. It was in the early half of the Jomon period (~14,500 to ~300 BC) [9] where Jomon people developed a high-level civilization evidenced by uncovering of the world oldest and most abundant high-quality earthenware [10] as well as large buildings in the Kanto area of Japan. Due to melting ice by those warming periods, Jomon people experienced so-called Jomon Sea Advance which made a deeply-intruding coastline in the Kanto area, making excellent bays for their ships as a means for travels and trades [11].

3.4. Kikai-Akahoya eruption to spread Jomon people and culture

The Kikai Caldera located on the seafloor in the south of the Kyushu Island of Japan and the Akahoya layer are evidences that one of the largest volcanic eruptions occurred around 5,250 BC [12]. Its volcanic ash is estimated to have covered a huge area of 2 million km^2 over the southwestern part of Japan and the southern part of the Korean Peninsula. Due to the volcanic ash falling from the Kikai-Akahoya eruption, Jomon people must have had to flee to the surrounding area including Southeast Asian islands, northern Korean Peninsula, and the southeast coast of Eurasia at least.

Because of their high skill in marine navigation, Jomon people could have reached farther even before the Kikai-Akahoya eruption to as far as the Middle East to form Sumerian civilization [13] (starting in 4,400±1,100 BC) which was the oldest civilization known before Jomon civilization. There is high similarity between Jomon and Sumerian civilizations such as agglutinative language, duodecimal calendar, imperial emblem

(chrysanthemum crest), and three sacred treasures (mirror, jewel, and sword). Some of their descendants could have returned to Japan after Nothern Israel perished in 722 BC as several waves of immigrating Isrelites and Jews through the end of Kofun period (300-538 AD) [14] as evidenced by similarities in words, shrine structure, myth, and religious rituals [15], and the discovery of Jew-looking Haniwa [16]. Although recent genome analyses may not conclusive in proving any clear Japan-Israel connection, the Israeli culture could have been so strong that several waves of even a small number of Israelite immigrants could have influenced the Japanese culture from its founding in 660 BC to the Kofun period.

4. Summary

Our planet Earth is highly special in that it allowed a long-term environmental stability for life to evolve to the highest level of human species and help them to develop science. In spite of its high stability, minor climate changes are the natural cycle of its evolution, and have also been important factors for human civilization to develop. The atmospheric CO_2 level decreased to the lowest level to allow room for humankind to burn wood and utilize fossile energy accumulated by prior lifeforms. Antarctica moved to the South Pole in time for humankind to utilize it as a time capsule containing the environmental history of the Earth and fossils of the Solar System. In addition, it is possible that a sea level rise formed excellent sea ports for Jomon people to develop a high-level skill in marine navigation, and that subsequent Kikai-Akahoya eruption forced them to migrate to the rest of Asia to spread its advanced civilization.

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The waters: nucleosynthesis of oxygen in stars

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Abstract: In Genesis 1:2, when God created the heaven and the earth, "the earth was formless and empty, and the Spirit of God was hovering over the waters." In modern science, waters are synthesized significantly later after the creation of the universe. The phrase "the water" in Genesis may symbolize life, which is the purpose of the creation: the waters are the key element that enables life on Earth. In the present presentation, we review the origin of oxygen, a constituent of chemical waters, synthesized in red giant stars, and discuss the recent results of the study on nuclear reactions, specifically radiative α capture on carbon-12 at low energies, updated following the previous presentation in the first international conference of ICHJA.

Keywords: Creation of the universe, the waters, synthesis of oxygen-16, red giant star, radiative alpha capture on carbon-12

1. Introduction

In Genesis 1:1-3, the holy scripture [1] tells us ``In the beginning God created the heavens and the earth. Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters. And God said, "Let there be light," and there was light.'' Those verses of the holy scripture may infer that the universe started with a big explosion, so-called big bang, which is now supported by the evidence studied in modern science [2]. The purpose of the creation in the biblical sense is the creation of Adam and Eve [1], the human being, and the environment for them. The origin of life is still one of the important questions to answer in scientific communities, while ``the waters'' are a key element of the existence of life. For example, about 60% of the human body is water; the elements of the human body are 65.0% oxygen in weight, 18.5% carbon, 9.5% hydrogen, 3.2% nitrogen, and so on [3]. Most of the Earth's surface, 70.8%, is covered by the ocean water, and the atmosphere of the Earth is composed of 78.1% nitrogen, 21.0% oxygen, 0.9% argon, etc. [4]. In addition, to search for extraterrestrial life, astronomers are studying the composition of extrasolar terrestrial planets similar to the Earth [5,6]. As seen in the verses in Genesis, ``the waters'' existed before the creation of the heavens and the earth, and it may symbolize the purpose of creation, that is, the creation of life.

In modern science, the chemical water, H_2O, is synthesized in the later stages after the creation of the universe. Just after the Big Bang, a large amount of hydrogen-1 (proton), about 70% in weight of the matter of the whole universe, along with 25% helium-4, 0.01% deuterium and helium-3, and a tiny amount of lithium-7, were synthesized, known as the big-bang nucleosynthesis (BBN) [7]. While the other elements, heavier than lithium-7, are synthesized in stars. The production process of the heavier nuclei is initiated by the triple collisions of helium-4, producing carbon, known as the triple-alpha process in the helium burning process [8]. However, the reaction takes place very slowly. It takes tens of thousands of years to convert a significant amount of helium to carbon, requiring a much higher density in red giant stars. During the helium burning process, the reaction, radiative α capture on carbon-12, $^{12}C(\alpha,\gamma)^{16}O$, is also possible. This reaction converts pre-existing and newly synthesized carbon-12 to oxygen-16.

The radiative alpha capture on carbon-12, $^{12}C(\alpha,\gamma)^{16}O$, is one of the fundamental reactions in nuclear astrophysics, which determines, along with the triple-alpha reaction, the C/O ratio in the core of a helium burning star [9]. It provides an initial condition for computer simulations of star evolution [10,11], and leads to a significant influence of star explosions and nucleosynthesis [12]. The reaction rate, or equivalently the astrophysical S factor of $^{12}C(\alpha,\gamma)^{16}O$ at the Gamow-peak energy, EG = 0.3 MeV, however, has not been measured in an experimental facility because of the Coulomb barrier. One needs to employ a theoretical model, fit the model parameters to experimental data measured at a few MeV energy, and extrapolate the reaction rate to EG. While it is known that $E1$ and $E2$ transitions are dominant due to the subthreshold 1^-_1 and 2^+_1 (l^π_{ith}) states of ^{16}O, whose binding energies relative to the α-^{12}C breakup energy are $B1$ = 0.045 MeV and $B2$ = 0.245 MeV, respectively [13]. During the last half-century, many experimental and theoretical studies on the reaction have been carried out. For review,

refer, e.g., to Refs. [14-18]. In the first international conference of Hyojeong Academy 2023 (ICHJA2023) [19], I reported the result of the estimate of the *SE1* factor of *E1* transition of $^{12}C(\alpha,\gamma)^{16}O$ at *EG* by constructing an effective field theory (EFT) [20]. In this presentation, I will report the updated results of the study of the estimate of *SE2* factor of *E2* transition of $^{12}C(\alpha,\gamma)^{16}O$ at *EG* by employing the EFT [21].

The present extended abstract is organized as follows. In Section 2, we review the formalism of the EFT for the α-^{12}C system and the previous result of the estimate of *SE1* factor of $^{12}C(\alpha,\gamma)^{16}O$ at *EG*. In Section 3, we report the updated result, made after the previous presentation, of the estimate of *SE2* factor of $^{12}C(\alpha,\gamma)^{16}O$ at *EG*. We especially discuss the difficulty of estimating the *SE2* factor. Finally, in Section 4, we present the results and discussion of this extended abstract.

2. Effective field theory for the alpha-carbon-12 system

In the presentation of the first ICHJA2023 [19], I reported the study and calculated the *SE1* factor of *E1* transition of $^{12}C(\alpha,\gamma)^{16}O$ at *EG* constructing an EFT [20]. An EFT is a standard theoretical method in hadron physics and few-body physics, but it is a rather new method for the study of nuclear reactions at low energies for nuclear astrophysics [22,23].

One may construct an EFT by using the methodology of quantum field theory [24-26]. When constructing an EFT, one first chooses a typical scale of a reaction to study and then introduces a large scale by which relevant degrees of freedom at low energy are separated from irrelevant degrees of freedom at high energy. We choose the Gamow-peak energy, E_G = 0.3 MeV, as a typical energy scale; a typical momentum scale would be $Q = \sqrt{2\mu E_G}$ = 40 MeV where μ is the reduced mass of the α-^{12}C system. Because the typical wavelength of the reaction, Q^{-1} = 4.8 fm, is larger than the size of the nuclei, nucleons inside of the nuclei would be irrelevant; we assign α and ^{12}C as structureless (point-like) 0^+ state of scalar fields. We then choose the energy difference between p-^{15}N and α-^{12}C breakup energies of ^{16}O; ΔE = 12.13 – 7.16 = 4.97 MeV, as the high energy (separation) scale; the high momentum scale is $\Lambda_H = \sqrt{2\mu\Delta E} = 160$ MeV. The theory provides us with a perturbative expansion scheme, and the expansion parameter would be $Q/\Lambda_H = 1/4$. The p-^{15}N system is now regarded as irrelevant degrees of freedom and integrated out of the effective Lagrangian, whose effects are embedded in the coefficients of terms of the Lagrangian. Those coefficients can, in principle, be determined from the mother theory, while they, in practice, are fixed by using experimental data. Because of the perturbative expansion scheme of EFT, by truncating the terms up to a given order, one can have an expression of reaction amplitudes in terms of a few parameters for each of the reaction channels. I have made use of this theory to study various cases of elastic α-^{12}C scattering at low energies [27-31], an estimate of S_{E1} factor of *E1* transition of $^{12}C(\alpha,\gamma)^{16}O$ at *EG* [32], and β delayed α emission from ^{16}N [18] up to the sub-leading order within the cluster EFT. The experimental data of the reactions are well reproduced by the fitted values of the parameters in the reaction amplitudes.

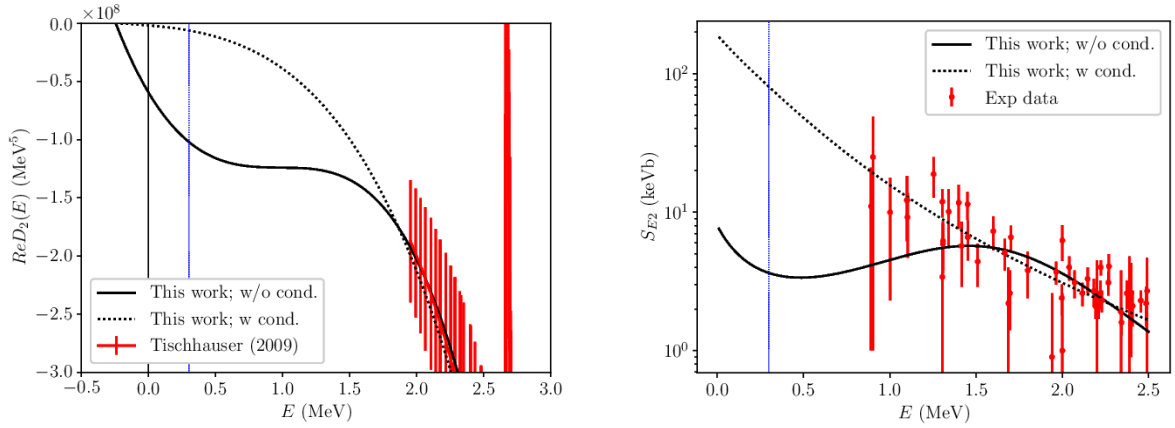
In the first ICHJA2023, I reported my result of the estimate of S_{E1} factor of *E1* transition of $^{12}C(\alpha,\gamma)^{16}O$ at *EG*. Up to the sub-leading order, the *E1* transition amplitudes are parameterized by five constants, and three of them are fitted to the phase shift data of elastic α-^{12}C scattering for p-wave [33]. The phase shift data are found to be well fitted by three effective range parameters for p-wave [28], and an estimated value of asymptotic normalization coefficient (ANC) of 1_1^- state of ^{16}O, which is calculated by using the three effective range parameters, are in good agreement with the values found in the literature [34]. The other two parameters, $h_R^{(1)}$ and $y^{(0)}$, are the counter term of the three-point γOO^* vertex and the coupling constant of αCO vertex, respectively. The coefficient $h_R^{(1)}$ subtracts the infinities from the loop diagrams, and $y^{(0)}$ is related to the ANC of 0_1^+ ground state of ^{16}O. The two coefficients are fitted to the experimental data of the S_{E1} factor up to E = 3 MeV, where E is the initial energy of α-^{12}C system in the center-of-mass frame. By using the fitted values of the parameters, I extrapolate the S_{E1} factor to E_G = 0.3 MeV and have

$$S_{E1} = 59 \pm 3 \quad \text{keVb}, \tag{1}$$

where I obtained a small, about 5% error bar. I also obtained a small center value compared to those in the literature, while it is in good agreement with those within about 30% errors of the S_{E1} factor at *EG* [32].

3. Estimate of astronomical S_{E2} factor of *E2* transition of radiative alpha capture on caron-12

In this extended abstract, I report the result of the estimate of S_{E2} factor of $E2$ transition of $^{12}C(\alpha,\gamma)^{16}O$ at E_G studied by employing the cluster EFT [21]. The $E2$ transition amplitudes of $^{12}C(\alpha,\gamma)^{16}O$ reaction can also be represented by five parameters, as in the case for the $E1$ transition amplitudes. The three of them can be fixed by using the phase shift data of elastic α-^{12}C scattering for d-wave, and the other two constants are fixed by using the experimental data of S_{E2} factor. However, I found difficulties in fitting the parameters by both methods for the case of the $E2$ transition.



(**a**) (**b**)

Figure 1. (**a**) Real part of the inverse of the dressed oxygen-16 propagator for d-wave, $ReD_2(E)$, plotted as a function of the energy E of the α-^{12}C system in the center-of-mass frame. A solid line is plotted using the values of the effective range parameters, r_2, P_2, Q_2, in the third column in Table 1 in Ref. [21], and a dotted line by those in the fourth column in the same table. The phase shift data reported by Tischhauser et al. (2009) [33] are converted and displayed in the figure as well. (**b**) S_{E2} factor of $E2$ transition of $^{12}C(\alpha,\gamma)^{16}O$ plotted as functions of the energy E of the initial α-^{12}C state in the center-of-mass frame. The two lines are plotted by using the parameters fitted to the experimental data of S_{E2} factor where the data are displayed in Figure 1 (a) as well. The vertical lines are drawn at E_G = 0.3 MeV. Both figures are taken from Ref. [21].

In Figure 1(a), I plot the real part of the inverse of the dressed oxygen propagator for d-wave, $ReD_2(E)$, as a function of the energy E of the initial α-^{12}C system in the center-of-mass frame. Two lines in the figure are plotted by using the fitted values of the three effective range parameters, r_2, P_2, Q_2, to the phase shift data of elastic α-^{12}C scattering for d-wave where the three parameters are represented as a cubic equation in the energy E. A (decreasing) cubic function can in general exhibit three patterns: 1) having a minimum point and a maximum point, 2) having a plateau, and 3) simply decreasing. I have applied a condition to make a line simply decrease when fitting the parameters to the experimental data. One can see that one line has a plateau and another one simply decreasing, but both lines reproduce the experimental data equally well. However, they draw different paths in the small energy region. Because the dressed oxygen propagators appear in the $E2$ transition amplitudes, it is crucial when I extrapolate the S_{E2} factor to E_G = 0.3 MeV.

The different paths in Figure 1(a) are related to the values of the ANC of 2_1^+ state of ^{16}O. The ANC is proportional to the inverse of the square root of the slope at E = -B_2 where B_2 is the binding energy of the 2_1^+ state of ^{16}O. Thus, the small negative slope of the dotted line at E = - B_2 leads to a large value of the ANC, while the large negative slope of the solid line leads to a small value of the ANC. I have the values of the ANC, $|C_b|_2 = 22.8 \times 10^4$ $fm^{-1/2}$, for the dotted line and $|C_b|_2 = 3.24 \times 10^4$ $fm^{-1/2}$, for the solid line [21]. Those values are different from the value of the ANC deduced from the α-transfer reactions, $|C_b|_2 = 10.7(3) \times 10^4$ $fm^{-1/2}$ [35]. Thus, I confirmed that the ANC of the 2_1^+ state of ^{16}O cannot be deduced from the elastic scattering data of the α-^{12}C system. To deduce the ambiguity, I employ a value of the ANC deduced from the α-transfer reactions.

In Figure 1(b), the two lines of the S_{E2} factor of $E2$ transition of $^{12}C(\alpha,\gamma)^{16}O$ as functions of the energy E of the α-^{12}C system in the center-of-mass frame. The additional two constants, $h_R^{(2)}$ and $y^{(0)}$, are fitted to the experimental data of the S_{E2} factor displayed in the same figure. One can see that the energy dependence of the S_{E2} factor at the small energy region, E = 0 – 1.5 MeV, stems basically from that of the real part of the inverse of the dressed oxygen propagator, $ReD_2(E)$, in Figure 1(a). To restrict the ambiguity in the values of the effective range

parameters for d-wave, I employ a value of the ANC, $|C_b|_2 = 10 \times 10^4 \ \ fm^{-1/2}$, and extrapolate the S_{E2} factor to E_G = 0.3 MeV, and I have

$$S_{E2} \ = \ 42 \ \pm \ 14 \quad \text{keVb}, \tag{2}$$

where I have a large, about 33% error bar. The error stems mainly from the large and scattered errors of the experimental data of the S_{E2} factor displayed in Figure 1(b).

4. Results and discussion

In this extended abstract, I briefly reviewed the creation of the universe and the synthesis of oxygen-16 in the helium burning process in stars, and reported the result, an estimate of the S_{E2} factor of the $E2$ transition of $^{12}C(\alpha,\gamma)^{16}O$ at E_G in the framework of the cluster EFT. The estimate of the S_{E2} factor still has a large uncertainty, and it is important to reduce the error by including the other available experimental data in the parameter fit.

The story of the creation of the universe in the scriptures becomes a quantitative study in modern science. The teachings in the scriptures are still important for one's spiritual life, as Jesus told in John 16:25 [1], ``Though I have been speaking figuratively, a time is coming when I will no longer use this kind of language but will tell you plainly about my Father.'' It may not be an easy task, but to explore spiritual truth is a valuable task in modern society.

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What we can guess about the spiritual world

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Abstract: Scientifically speaking, we know nothing about spiritual reality, as all our instruments are based on electromagnetism. There appears to be no way to apply the scientific method to explore the spiritual realm, so we are left with theorizing and constructing hypothetical models. The first and most fundamental assumption—one that can be taken as an axiom—is that the spiritual reality is non-material. This assumption alone opens some room for reflection. In this paper, I present a set of axioms, statements, and hypotheses that seem relevant within the current state of our understanding of spiritual reality. These statements are, for now, speculative and cannot be scientifically verified or falsified. Nevertheless, such work is worthwhile as a starting point for discussion and for gradually improving the model. In particular, I argue about time and energy in both realms: while in physical world they play the main role, in spiritual one it might not have the same importance. In this paper I present a list of questions about spiritual reality that are to be answered primarily from my viewpoint.

Keywords: spiritual world, symmetry

1. Introduction

At this point, such a discussion—or paper—cannot be truly scientific, because modern science is based on the scientific method, which is not applicable to spiritual reality. The scientific method requires interaction with the object under study, the ability to perform precise measurements, and the possibility to repeat experiments with consistent results. However, all our scientific equipment operates based on electromagnetism, which permeates the physical world, while there is no evidence that it has any connection to the spiritual realm. Therefore, we cannot perform any measurements to confirm or reject such a theory. For this reason, most scientists tend to ignore this field, leaving it to faith and religion. Yet, I believe a true scientist would never dismiss something solely because it cannot be tested at present. Thus, physical science and its methods will not be able to directly help us understand the reality and laws of the spiritual world.

2. Axioms

Any theory begins with axioms — statements that are unprovable within the theory itself but serve as its foundation. We choose these axioms based on our own judgment and understanding, hoping they are true or at least as close to reality as possible. Here are 4 of them I propose in this model.

2.1. Spiritual world exists

This axiom is quite obvious — a null assumption. If it is wrong, then there is nothing to discuss, and the whole theory falls apart. So far, we have no scientific proof of this statement, which implies either that it is incorrect or that we are not yet developed enough to detect it. On the other hand, subjective human experience throughout the entire history of humankind attests to its existence. Therefore, within this theory, we accept this statement as true.

2.2. Spiritual world is not material

There is not enough data to confirm this statement, but it seems reasonable if we want to resolve the contradiction of not detecting the spiritual realm with our equipment. However, there is always the possibility that we *do* detect it but mistake it for some manifestation of physical reality. This could indeed explain some inconsistencies in our understanding of the world around us, including phenomena such as dark matter and dark energy. For now, as a null hypothesis, we will regard this statement as true.

2.3 Both realities were created by the same Creator

The idea of Creation is, of course, still a subject of ongoing discussion. Cosmology and physics, in general, can shed light on moments close to the beginning of our Universe — but only from this side of the zero point. What came before that is even a non-valid question, because the concept of "before" requires time to exist, and the existence of material objects is necessary for the existence of time. Material objects, however, only appeared after the beginning of the Universe. Thus, the origin of the Universe remains a mystery. Throughout the ages, the majority of humanity has been convinced that the Creator exists. In the context of our model, this axiom is indispensable because it provides the only means to gain insight into the spiritual world through the principle of similarity. It is a common property of any creation to resemble both the internal and external nature of its creator. If we assume this is true for the Creator of our Universe, and that the spiritual reality was made by the same Creator, then we have a method to understand something about the spiritual reality by studying the physical one. Therefore, within this theory, we consider this statement to be a fundamental truth.

2.4 Creator is a parent to humans

Explaining reality and answering the question of *how* it exists is one thing — but *why* it exists is an entirely different matter. Modern science primarily focuses on the “how” questions about the Universe. Introducing such an axiom opens the door to asking the “why” question. This, in turn, allows us to speculate about the reason behind the creation of two worlds and may offer hints about their purpose. I will not explore this topic in detail in this paper.

3. Statements

Based on the presented axioms there are several statements that we can make and that seem to be true. Here are some of them, at least those that may seriously help us on the way of exploration.

3.1 Scientific method does not work in spiritual world exploration

This statement was discussed in the introduction and appears quite firm — at least until a well-justified method to quantitatively interact with spiritual reality emerges, if it ever does.

3.2 We can interact with spiritual world

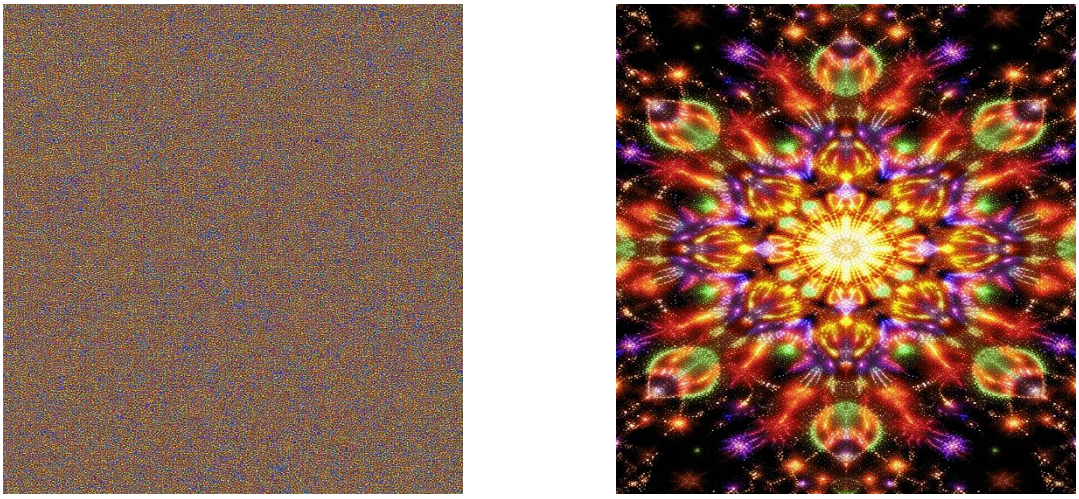
On one hand, we have no equipment capable of detecting the spiritual world. Yet, on the other hand, there is the undeniable fact that our body interacts with our spirit — if we accept the first axiom and assume that human beings possess a nature more complex than just the physical body. In this sense this statement seems obvious.

3.3 We can rely upon the principle of similarity in exploring the spiritual world

Under the third axiom, this statement becomes obvious. Without it, we are doomed to the endless efforts of a blind person wandering in a crowded hall, trying to accidentally find knowledge about the spiritual world.

4. Laws and symmetries

Both plots in Fig. 1 consist of same color pixels, but the difference is striking. The left one is completely chaotic — and we may define chaos as the absolute absence of symmetry. The right one, however, exhibits polygonal symmetry. A physical scientist would say that some laws govern the placement and color of pixels, while a mathematician would recognize the symmetry and identify the corresponding group. Indeed, any law can be seen as a reflection of some underlying symmetry. Symmetry is an abstract concept in mathematics and, unlike physical laws, it is not based on empirical observation. This makes it a potential bridge to understanding spiritual laws— if we can hypothesize about symmetries in the spiritual realm. Guessing these symmetries is not an easy process, but it is at least a way to gain insight into a world we otherwise seem unable to observe. Based on the principle of similarity, we may hope that the spiritual reality is governed by laws as well—and thus may be studied and understood. After all, if it were entirely chaotic, it would be completely incomprehensible.



(a) (b)

Figure 1. A set of color pixels: (a) chaotic; (b) in polygon symmetry.

The famous Noether's theorem (Fig. 2) states: Every continuous symmetry of the action leads to a conservation law. Once we guessed the symmetry, we can derive certain conservation laws and thus build a model of the world. Let's consider an example. If we observe a symmetry under 3D spatial rotations, we can associate the group SO(3) with it, which—by Noether's theorem—leads to the conservation of angular momentum components. If we then include symmetry under Lorentz boosts, the relevant symmetry group becomes SO(1,3), the special orthogonal group in pseudo-Euclidean space, which leads to the conservation of the relativistic angular momentum tensor. Finally, incorporating invariance under spacetime translations yields the full Poincaré group, ISO(1,3), which is a semi-direct product of SO(1,3) and $\mathbb{R}^4$ and serves as the fundamental symmetry group of special relativity, and invariance under it is a necessary condition for any physical theory formulated in Minkowski space. If a theory is invariant under the Poincaré group, we can conclude that it respects the principle of relativity as formulated in special relativity. If one could identify symmetries within the spiritual realm and construct a corresponding symmetry group, then—by analogy with physics—it might be possible to formulate conservation laws and establish a meaningful criterion for validating theories about its nature.

Our Universe is material, and within it the concepts of space and time are defined (Fig. 3). But what is space, really? When we say "here" and "there", "closer" or "farther", we are always referring to positions relative to material objects—we cannot define space in any meaningful way without them. Similarly, when we introduce the concept of time and its units of measurement, we do so through the motion of one material object relative to another. Thus, both the concepts of space and time require the existence of matter to be meaningfully defined. Moreover, certain properties of these entities—specifically, the homogeneity of time and space—lead, via Noether's theorem, to the conservation laws of energy and momentum, respectively.

The spiritual realm, by contrast, is not material—assuming the previously introduced axioms. Therefore, space and time either do not exist within it, or, more plausibly, do not play as crucial a role as they do in the physical realm. But then it means that in spiritual realm energy and force do not play such a crucial role as in the physical one and that implies that spiritual realm is a realm of limitless energy!

How can we account for the idea of infinitely available energy? One possible explanation could lie in the concept of the Multiverse—or more specifically, in the idea that at every moment, the Universe splits into numerous parallel universes, each realizing a different possible state. This notion is reminiscent of the Many-Worlds Interpretation of quantum mechanics, where every quantum event results in a branching of the Universe into distinct outcomes.

Another idea is that human nature may be multidimensional. While we live and perceive reality within a physical four-dimensional world, our additional dimensions—if they exist—might be hidden or folded in ways that are currently inaccessible to our perception. This may be like a butterfly: while fully developed, it can live and move freely in three dimensions. But during its maturation phase, as a chrysalis, this ability lies dormant, and it seems confined to a more limited, almost two-dimensional existence. When a butterfly hatches, it leaves behind

its two-dimensional shell and becomes a fully three-dimensional being. If we accept the validity of the principle of similarity, this analogy seems the most compelling to me. Consider this: if you restrict the movement of your leg for a long period, the muscles will atrophy, and you may even forget that you once had the ability to move it in this direction. In a similar way, our true essence may be unable to move freely in dimensions beyond the familiar four while it is bound to the physical body. But when our physical existence ends, that essence may finally stretch its wings and experience the fullness of multidimensional being—like a butterfly emerging into flight.

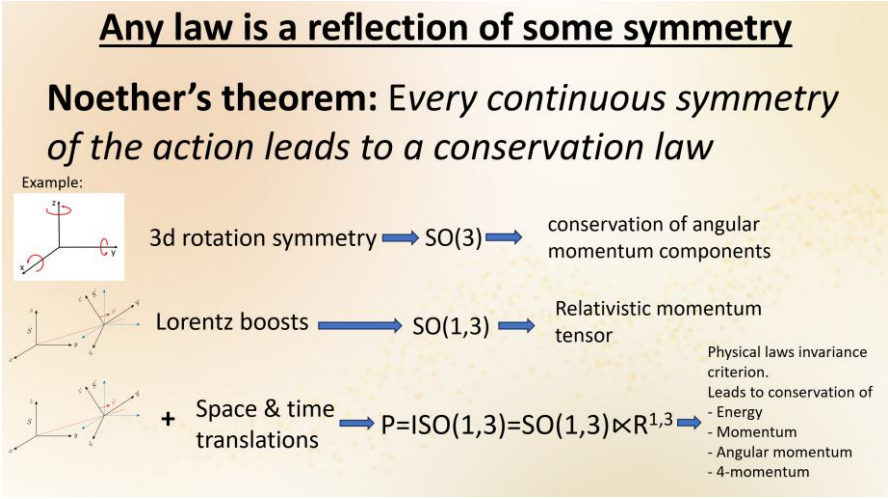


Figure 2. Noether's theorem and an example of the Poincaré group.

The Universe appears to be self-similar, which makes it reasonable to search for analogies within the physical world. In this sense, physical science may not be able to directly explore the non-material, spiritual realm, but it holds great potential as a source of analogies especially when guided by mathematics and the principle of similarity.

I heard that the late Dr. Sun Myung Moon, founder of the Family Federation, once said that in the spiritual world, if you want to organize a feast for a million people, you can do it instantly. In this understanding of spiritual reality, this would be true, because there is no law of energy conservation there, and energy itself does not play such a crucial role.

Why, then, don't we get to live in a world of limitless energy from the very beginning? Science teaches us that everything in nature is made the way it is for a reason. The caterpillar stage is necessary for the future butterfly to gain strength and prepare for reproduction—in other words, to mature. It moves slowly, eats a lot, and at that stage, it doesn't need to fly. It's natural to use this analogy and ask: what could be the reason that a multidimensional human essence is restricted to just 4D? Perhaps it is a kind of maturation process needed to prepare us for our true, higher existence. One of the things life in the physical world teaches us is to follow laws. Laws reflect symmetries, so we might guess that this life is preparing us for a world of greater symmetries. The idea of a law is that if you violate it, you lose harmony—if you jump from the fifth floor instead of using an elevator, you will be injured or even die due to the law of gravity. In a world of higher symmetry, if you don't have the habit of following laws, the consequences might be even more severe than they are here. Physical reality is more chaotic. Even our bodies, while quite symmetric, are not completely so. This reality possesses fundamental symmetries, but it is far from being fully deterministic. In the limited 4D world, actions take time—you have a chance to stop yourself if you realize you are wrong. And even if you make a mistake, there may be time to correct it. In addition, there is a limit to the amount of energy you can use in the physical world. So, if you make a wrong decision, the damage may be limited. In this sense, the physical world is an excellent training ground.

If so, maturity for us means the ability to naturally follow the laws of the world around us. We were created for a certain purpose set by the Creator. The world must be designed in a way that helps us realize this purpose. When we follow our desires, we use critical thinking and adjust our behavior to align with the laws of the world. In doing so, we gradually form a system of values that begins to guide our actions. The result of this process is a

value system that corresponds to the laws of the world around us. Since this system is not material, I believe it is a good candidate for the ultimate goal of our life in the physical world — a goal that signifies true maturity and marks our readiness for the next stage. To perform any action, one needs both will and energy. Energy is limited in the physical world, which makes it a safe environment to train our will and our system of values, including the initiative to follow fundamental symmetries.

What is a major distinctive feature that humans possess in this Universe? It is our creative ability. From the perspective of physics, what does any act of creation involve? It reduces entropy. It transforms objects of lower complexity and value into ones of higher complexity and value. Creation brings greater order to the system — in other words, it increases symmetry. In thermodynamics to reduce a system's entropy, it must release excess thermal energy. Even this looks as a hint to us – giving, not receiving is our distinctive feature.

This concept may be extended beyond purely physical cases — I believe it also applies to human relationships. Indeed, altruistic acts use one's own energy and resources to create something of higher order and value. In contrast, selfish acts often consume what is unnecessary for the individual, merely to satisfy personal desires, thereby preventing those resources from being used for a greater good. So, our most distinctive feature is — in physical terms — the ability to reduce entropy, and — in mathematical terms — the tendency to increase symmetry in the world. Why is this the case? Perhaps this is the central lesson we are meant to learn in our current state of existence. If so, then this stage of life is preparing us to live in a world of greater symmetry. Indeed, living for something greater than ourselves seems to be embedded in the very structure of the Universe — it teaches us to live this way. Could this be a clue pointing toward a fundamental symmetry in the spiritual realm?

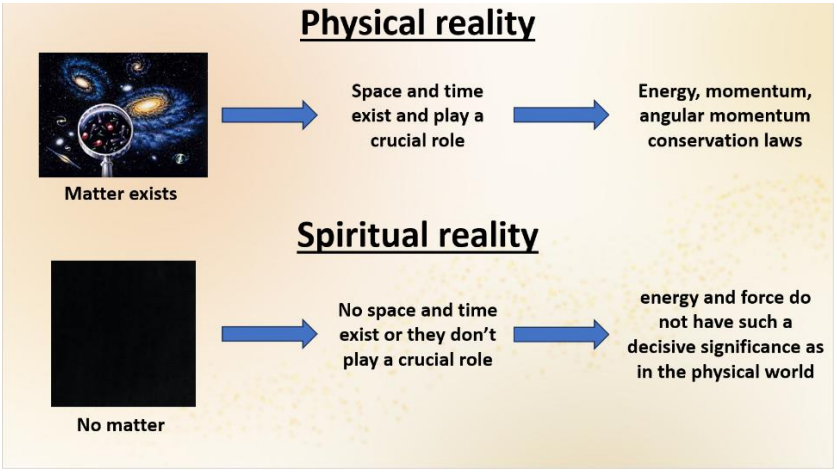


Figure 3. Presence of matter introduces concepts of space and time and makes physical reality radically differ from the spiritual reality.

Why don't we see spiritual reality? Or perhaps we *do* see it — but fail to recognize it, unable to distinguish it from the physical world. We simply don't know how to perceive it. From birth, we are conditioned to think in terms of time and space. We live in a world where everything is finite, and time only moves in one direction - forward. As a result, we struggle to grasp concepts like infinity or eternity. If you were to think deeply about these things for a whole day, you might well lose your mind. And yet, such concepts may be entirely natural in the non-material world. I believe that if we were exposed to spiritual reality from birth, we could adapt our minds to these more abstract concepts. But after years of living solely in a four-dimensional world, it becomes almost impossible. Just as comprehension of the most complex areas of mathematics is only achievable by those who live and breathe it day and night for decades — sometimes becoming what we call "not of this world" — so too is it extremely difficult for a brain shaped by a 4D reality to truly grasp a multidimensional one.

Perhaps it's not such a bad thing that most of us don't fully comprehend spiritual reality — at least, not yet. After all, we still struggle to live in harmony with the basic physical world. Maybe we're simply not ready to engage with a more symmetric, higher-order reality.

5. Conclusions

A sad conclusion we may draw is that we currently have no objective knowledge of the spiritual realm. Many religions describe it in their own unique ways, and many individuals share personal experiences related to the spiritual world. But these accounts are inherently subjective and cannot serve as the foundation for a coherent, unified theory. Due to the lack of tools or methods to explore the spiritual dimension in a scientific manner, science has largely left it to the domain of religion. As a result, we lack a clear theoretical framework or model of the spiritual world, and we are unable to describe its properties or how it might interact with the physical realm.

5.1. Guesses

For now, all we can do is make guesses about spiritual reality. Of course, these guesses depend on the model we assume. Here are a few assumptions or insights we can propose within the framework of our current model.

5.1.1. If we guess fundamental symmetries of the spiritual world, we can derive its laws and create its model

Instead of blindly searching for something beyond the physical, we can at least find some clues through our understanding of the physical world and the principle of similarity. Only time will tell how valuable these clues truly are — but at least they offer us something to work with.

5.1.2. The Universe teaches us to follow laws, so it prepares us for a world of higher symmetries

In principle, we could imagine a far less symmetric world — one where chaos reigns. But instead, we find ourselves in a world governed by strict, discoverable principles — and we are intelligent enough to recognize them. That must mean something. What is the ultimate purpose of these laws, if not this very realization?

5.1.3. Human's distinctive feature is an ability to reduce entropy, so it may have the highest value for life in spiritual world

Physically — and even genetically — we are quite similar to some animals. Yet, in the world around us, we see no other beings with creative abilities even remotely comparable to those of humans. If not this, then what else could be our truly distinctive feature? And if not the act of bringing symmetry to the chaos of the world — by living for the sake of a greater good — then what else could be our mission and ultimate goal?

5.2. Questions

And, of course, at this point, there are far more questions than answers — or even guesses. Here are just a few of them.

5.2.1. What symmetry corresponds to the living for the grater good principle?

If this guess is correct — and symmetry (or a similar principle) truly lies at the core of the spiritual realm, just as it does in the physical one — then once we identify it, we might be able to find a corresponding group structure and begin developing a mathematical model of spiritual reality.

5.2.2. How much more symmetrical is the spiritual reality compared to the physical one?

If we say that the spiritual world is a realm of greater symmetry, it's only natural to ask: How much more deterministic is it?

5.2.3. How actively spiritual world interacts with the physical one?

As mentioned earlier, we know nothing for certain about spiritual reality — and we may simply fail to distinguish its influence on the physical world from what we call "unknown" physical laws. Take, for example, dark matter and dark energy. We observe something holding gas and stars together within galaxies, and something else accelerating the expansion of the Universe. In response, we build physical theories to explain these phenomena. But what if this reality is built upon the framework of a deeper, spiritual one — and what we observe is merely the manifestation of its influence? These are just two examples. How many other unresolved mysteries might be pointing in the same direction? I'm convinced that we *will* find the answers to these questions — and I believe we are standing on the threshold of a new era of great discoveries in this field.

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True Therapeutic Integration: How Acupuncture and Meditation Support Neuroendocrine and Musculoskeletal Health

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Abstract: According to Rev. Sun Myung Moon, "The body should follow the mind as its center. When the mind and the body become one, a person's character and actions naturally align with heaven." For many patients, their first encounter with meditation occurs unexpectedly during an acupuncture session. According to research, both meditation and acupuncture stimulate the body's regulatory systems, particularly the neuroendocrine and musculoskeletal systems to promote balance and healing. Together, they create a therapeutic experience that supports both mental and physical well-being. Meditation is often spontaneously induced during acupuncture treatments particularly once the needles are inserted and the patient is left to rest in a quiet, undisturbed environment for approximately 20 to 30 minutes. This naturally occurring meditative state enhances the therapeutic impact of acupuncture by activating neurophysiological mechanisms associated with mindfulness. Meditation has been shown to increase neuroplasticity, regulate key neurotransmitters such as serotonin, dopamine, and GABA to create a shift towards autonomic balance toward parasympathetic dominance. These changes promote emotional stability, downregulate the hypothalamic-pituitary-adrenal (HPA) axis, and foster greater coherence between the mind and body. Similarly, acupuncture modulates neurophysiology by stimulating afferent nerve fibers that transmit signals to the spinal cord and brain, activating regions involved in pain regulation, emotion, and autonomic control. This stimulation promotes the release of endogenous opioids, serotonin, dopamine, and GABA contributing to analgesia, mood stabilization, and parasympathetic activation. Additionally, acupuncture influences the hypothalamic-pituitary-adrenal (HPA) axis and often overlaps with dermatomes and myotomes, supporting both neurological and endocrine regulation. Acupuncture naturally relaxes the body, and in this restful state, the mind is often guided back to its center where the virtues of one's character and actions can naturally relax into the healing process. This paper articulates the therapeutic integration between meditation and acupuncture and how it supports neuroendocrine and musculoskeletal health. By recognizing the meditative potential inherent in acupuncture sessions, practitioners can more intentionally support this process and empower patients to extend these benefits beyond the treatment room by encouraging the adoption of simple mindfulness-based practices at home to reinforce nervous system regulation, emotional clarity, and overall well-being.

Keywords: Acupuncture, Meditation, Endocrine Hormones, Nervous System, Mindfulness

1. Introduction

The In modern integrative medicine, the interdependence of mind and body is no longer philosophical, it is physiological. Research in neurobiology and behavioral endocrinology reveals that both acupuncture and meditation regulate key systems responsible for homeostasis and healing. Meditation has been shown to influence neuroplasticity, modulate neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (GABA), and reduce activation of the hypothalamic-pituitary-adrenal (HPA) axis all contributing to improved emotional regulation and autonomic balance [1-3]. Both therapeutic methods are increasingly understood as complementary practices that converge on shared biological pathways. Acupuncture has been shown to stimulate peripheral afferent nerves that signal to the central nervous system, promoting the release of endogenous opioids and neurochemicals that alleviate pain, stabilize mood, and restore parasympathetic dominance [4-6]. The overlapping neurophysiological mechanisms of acupuncture and meditation supports the regulation of the neuroendocrine system, restores the musculoskeletal functions, and cultivates an embodied state of mindfulness.

Clinically, it is not uncommon for patients to enter a meditative state during an acupuncture treatment. The stillness of the room, the insertion of needles, and the uninterrupted period of rest create a therapeutic environment in which the nervous system downshifts, and mindfulness arises spontaneously. The vision of Rev. Dr. Sun Myung Moon, who emphasized the spiritual and energetic alignment between mind and body, resonates deeply

with the clinical evidence showing how inner harmony fosters health. His teachings echo through the lived experiences of patients whose emotional states and physiological responses improve when body and mind begin to align.

2. Acupuncture and Meditation

2.1. The Meditative State Induced by Acupuncture

Meditation is often taught as a seated practice focused on breathing and awareness techniques guided by an instructor. However, in an acupuncture treatment patients are told to relax as they lay on the table to receive needles all over their body. Acupuncture reduces activity in the limbic system including the amygdala and hippocampus which are areas linked to emotional reactivity and memory [4,5]. Once the needles are inserted the practitioner steps out of the room and the patient is left in stillness for 20 to 30 minutes. During this time, it is possible for the patient to experience a unique combination of sensory withdrawal, physical stillness, and autonomic down regulation that creates a fertile ground for spontaneous mindfulness. These changes were also observed during meditation, the self-referential thought and rumination are effects of the down-regulation of the default mode network (DMN) [3]. In clinical practice, this meditative state can also be supported by a mindful environment taking into consideration the lighting of the room, the sound system, the aesthetics of the room, and with minimal interruption can support profound emotional regulation and somatic release.

2.2. Neuroendocrine and Musculoskeletal Effects of Meditation

Mindfulness meditation has well-documented effects on brain function and endocrine balance. It enhances activity in regions like the prefrontal cortex and insula, improving attention, interoception, and emotional regulation [1]. This calms the HPA axis which helps to boost serotonin, dopamine, and GABA. Concurrently, it dampens activity in the amygdala, reducing fear and stress reactivity [7]. Chronic stress elevates cortisol, contributing to inflammation and mood disorders. Meditation also promotes neuroplasticity which is the brain's ability to reorganize and form new neural connections. Meditation lowers cortisol, regulates diurnal rhythm, and reduces inflammatory markers [8].

This adaptability not only supports recovery from trauma and chronic stress but may also enhance the efficacy of other treatments, such as acupuncture, by reinforcing the both neural and musculoskeletal patterns associated with stress management, promoting relaxation, reducing muscle tension, and potentially aiding in pain management and recovery. Meditation has also been shown to reduce oxidative stress in muscle tissue by lowering free radical levels, improving mitochondrial function, and reversing neurobiological changes linked to myofascial pain syndrome [9]. Additionally, by enhancing parasympathetic tone and reducing sympathetic overactivity, meditation alleviates trigger point sensitivity and associated emotional stress suggesting its value as an effective therapy for chronic myofascial pain. Practices like body scanning help patients become aware of where stress is held, increasing the likelihood of lasting somatic release [10]. Pain becomes less of a threat and more of a messenger, guiding the healing process. Meditation also helps patients build tolerance for uncomfortable sensations or emotions that may arise in the body, reframing pain as a signal rather than a threat.

Genesis of myofascial pain syndrome and the possible sites of action of meditation.

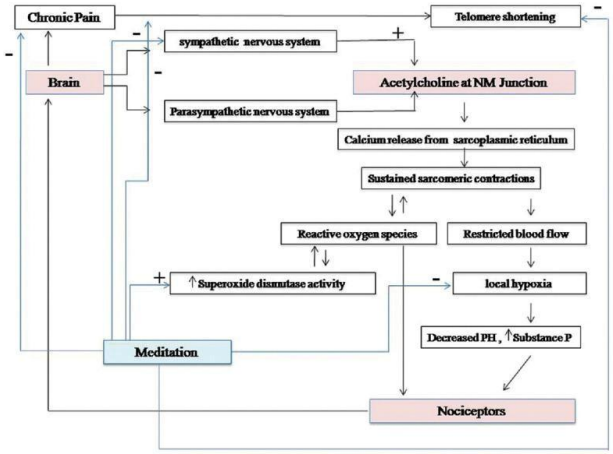

Figure 1. Neuroendocrine and Musculoskeletal Effects of Acupuncture.

Acupuncture engages both structural and signaling systems in the body. By stimulating specific points along the meridians, often near nerve endings or neuromuscular junctions, it activates afferent nerve fibers that communicate with the brain and spinal cord. This stimulation influences the hypothalamus, limbic system, and other regions involved in autonomic and emotional regulation [4,6]. As a result of this stimulation, research has shown that acupuncture also promotes the release of opioids, modulates serotonin, dopamine, and GABA which helps to reduce pain, anxiety, and other mood stabilizing effects [11,12]. As Rev. Dr. Sun Myung Moon stated, "Acupuncture is not merely a treatment for the body system, it speaks to the information system of the body. When the correct point is touched, the body receives a message, and healing begins at the level of communication, not just tissue." This frames acupuncture as a signaling modality, one that invites the body back into coherence, rather than forcibly manipulating it.

Chronic stress often manifests as muscle tension, restricted movement, or pain. Musculoskeletal health is stimulated in acupuncture by targeting dermatomes and myotomes, areas innervated by spinal nerves promoting localized muscle relaxation, improving circulation, and reducing pain. Acupuncture improves these conditions by reducing inflammation, restoring neuromuscular balance, and releasing fascial restriction [6]. This contributes to its efficacy in treating chronic pain, muscle tension, and postural imbalances, conditions often exacerbated by emotional or psychological stress. Additionally, by activating dermatomes and myotomes connected to the spinal cord, acupuncture can reset neuromuscular patterns and reduce somatic guarding, particularly in areas that unconsciously hold emotional tension, such as the neck, shoulders, jaw, and lower back.

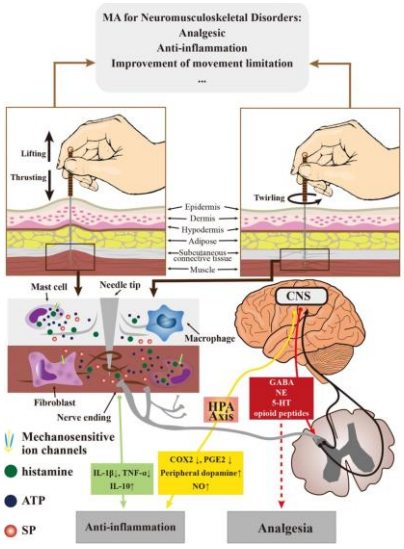

Figure 2. The effects of MA on neuro musculoskeletal disorders and the potential mechanism of action. (https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1096339/full)

2.3. *Synergistic Mechanisms of Meditation and Acupuncture*

Meditation and acupuncture converge by modulating the same networks: the autonomic nervous system, the HPA axis, and key neurotransmitter systems. Both reduce sympathetic tone, enhance parasympathetic activity, and promote emotional regulation through similar biochemical and neurological pathways [1,13]. The mechanisms of both meditation and acupuncture reveal a significant therapeutic integration rooted in their shared ability to modulate the neuroendocrine, musculoskeletal, and emotional networks that regulate well-being.

Their combined effects offer a true therapeutic integration towards neuroendocrine and musculoskeletal health. Acupuncture prepares the body by relaxing tissues and calming the nervous system, while meditation deepens receptivity and fosters conscious integration. Both practices downregulate the default mode network, supporting presence and interrupting cycles of rumination [3,5]. When paired, acupuncture facilitates physical release, and meditation helps the patient consciously process and integrate what surfaces. Patients may become aware of memories, emotions, or insights that surface during treatment as the body unwinds. This process can feel cathartic, grounding, or deeply restful, depending on the individual's nervous system state and level of readiness. This mind-body synchrony transforms the treatment room into a space for both physiological and psychological resolution.

From a clinical standpoint, this integration is invaluable. Many patients suffering from chronic musculoskeletal issues have exhausted purely physical interventions. By addressing both the structure and the story, the tissue and the tension behind it, acupuncture and meditation offer a true therapeutic integrated approach to healing that acknowledges the body as both a site and a signal of deeper imbalance. The result is not only pain relief, but a sense of reclamation that creates more space, profound stillness, and self-awareness within the body.

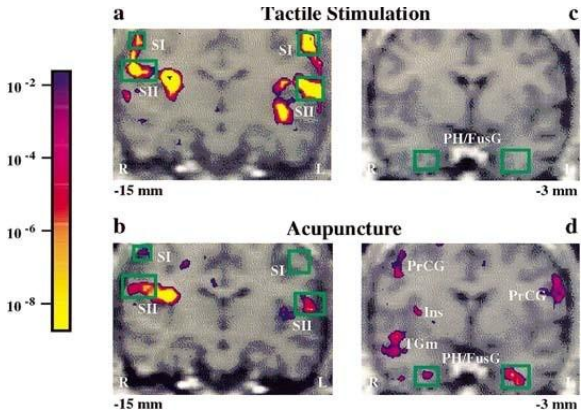

Figure 3. Bilateral fMRI signals in somatosensory cortices [4].

3. Discussion

Understanding the neuroendocrine and musculoskeletal synergy between acupuncture and meditation allows practitioners to refine their approach not only as technicians of the body, but as facilitators of internal coherence. The union Rev. Dr. Sun Myung Moon refers to between body and mind, action and character reflects a vital integration essential for healing. Clinically, this process mirrors the principle of yin and yang: complementary forces whose dynamic balance sustains physiological and psychological harmony. Though the boundary between mind and body may appear indistinct, bridging it is necessary to restore wholeness and achieve the functional equilibrium that practices like acupuncture and meditation support.

Small adjustments in clinical practice can have a significant impact on therapeutic outcomes. A darkened room, soft ambient music or silence, minimal interruption, and a longer needle retention time can help deepen a patient's parasympathetic state. Pausing for a few slow breaths before needling, or guiding a patient to "notice what they feel without judgment," invites awareness into the session without imposing formal meditation. These subtle cues help shift the focus from symptom management to self-connection. Engaging patients in dialogue about how meditation and acupuncture influence neuroendocrine and musculoskeletal health helps bridge the gap between Eastern and Western medical practices. This integrative conversation not only deepens patient understanding but also fosters a more holistic approach to healing.

Validating patients' internal experiences helps reinforce self-agency and body trust. For patients unfamiliar with meditation and acupuncture, this may be their first encounter with deep rest or emotional clarity. Practitioners can validate these experiences by briefly explaining the role of the nervous system in healing and encouraging simple at-home practices to reinforce them. Simple at-home practices such as breathwork, self-acupressure, or Qigong can help extend these benefits beyond the clinic and also help to regulate pain management. Patients should be supported in taking an active role in their healing process, fostering greater self-regulation, autonomy, and energy balance as part of integrative care.

In closing, Rev. Dr. Sun Myung Moon's insight that healing arises through intelligent signaling underscores the role of the practitioner as a translator of the body's language. Acupuncturists can help patients reconnect with their own systems of regulation, laying the foundation for long-term well-being.

4. Conclusion

Acupuncture and meditation share a fundamental truth: healing begins with communication between nerve fibers and hormones, between breath and awareness, between practitioner and patient. By downregulating the hypothalamic-pituitary-adrenal (HPA) axis, both practices reduce chronic stress signaling, lower systemic inflammation, and restore hormonal coherence. They modulate key neurotransmitters such as serotonin, dopamine, and GABA enhancing emotional stability, motivation, and physiological relaxation. Through this neuroendocrine regulation, patients experience not only symptom relief but deeper nervous system recalibration and long-term resilience.

Simultaneously, acupuncture and meditation address the musculoskeletal system not merely as structure, but as a dynamic interface between psychological and physical states. Acupuncture improves circulation, reduces pain, and re-patterns neuromuscular tension, while meditation enhances body awareness and emotional integration. Together, they dissolve stored tension and rewire stress-based holding patterns resulting in improved posture, proprioception, and ease of movement. This integration transforms the treatment experience. It interrupts old patterns, reawakens body awareness, and fosters presence. The acupuncture session becomes a gateway to embodied mindfulness, a space where deep healing unfolds not just in tissue, but in perception and connection that supports neuroendocrine and musculoskeletal health. This true therapeutic integration makes way for a clinical model that restores coherence across systems and reconnects the patient to their own innate capacity for balance, health, and embodied presence.

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The Relationship Between GSK3Beta Activity and TDP-43 Mediated Neuritis in Neurodegenerative Diseases

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Abstract: TDP-43-positive inclusions have also been reported to be associated with the hippocampal CA1 Lewy-body pathology of familial Parkinson's disease patients bearing a Parkin mutant suggesting that there is likely a link between Parkin and TDP-43. Also, it is known that loss of the nuclear RNA binding protein TAR DNA binding protein-43 (TDP-43) into cytoplasmic inclusions is the strongest correlate to neurodegeneration in frontotemporal degeneration (FTD) and amyotrophic lateral sclerosis (ALS). TDP-43, TAF15, and FUS are DNA/RNA binding proteins, and these lead to neurodegenerative disease when inducing cytoplasmic aggregates. Selective expression of TDP-43 in rat astrocytes also leads to non-cell autonomous neuronal toxicity. TDP-43 is ubiquitously expressed in many tissues and cell types, including glial cells of the central nervous system. Glycogen Synthase Kinase 3β (GSK3β) is a Serine/Threonine protein kinase that phosphorylate either threonine or serine and participates in a variety of cellular processes such glycogen metabolism, gene transcription, apoptosis and microtubule stability. To identify the mechanism of neuroinflammatory induction through over-expression GSK3β in astrocyte using Shaggy which is the homolog of GSKβ in Drosophila model. This experiment revealed that we were able to suppress astrocytes-induced neuroinflammation by regulating GSK3β activity in the TDP-43 ALS model.

Keywords: Glycogen Synthase Kinase 3β (GSK3β) 1, TDP-43 (TAR DNA binding protein-43) 2, Amyotrophic lateral sclerosis (ALS) 3

1. Introduction

The TDP-43 (TAR DNA binding protein-43)-positive inclusions have been reported to be associated with the hippocampal CA1 Lewy-body pathology of familial Parkinson's disease patients bearing a Parkin mutant suggesting that there is likely a link between Parkin and TDP-43. Also, it is known that loss of the nuclear RNA binding protein such TDP-43 is the strongest correlate to neurodegeneration in frontotemporal degeneration (FTD) and amyotrophic lateral sclerosis (ALS). Furthermore, TAF15 (TATA Box Binding Protein Associated Factor), and FUS (fused in sarcoma) including TDP-43 are DNA/RNA binding proteins, and these lead to neurodegenerative disease when inducing cytoplasmic aggregates. Selective expression of TDP-43 in rat astrocytes also leads to non-cell autonomous neuronal toxicity. TDP-43 is ubiquitously expressed in many tissues and cell types, including glial cells of the central nervous system. In other word, in the case of astrocyte and microglia activated by causative proteins such as TDP-43, cytokine and chemokines are secreted, which causes neurotoxicity that induces peripheral nerve cell death. Glycogen Synthase Kinase 3β (GSK3β) is a Serine/Threonine protein kinase that phosphorylate either threonine or serine and participates in a variety of cellular processes such glycogen metabolism, gene transcription, apoptosis and microtubule stability. Also, it is reported to activate glial cells such as astrocyte and microglia and stimulates pro-inflammatory cytokines secretion between GSK3β and inflammatory signaling pathway. In this experiment, we want to see if regulating GSK3β activity could weaken cystic TDP-43 intermediate neuroinflammatory in neurodegenerative diseases. We want to see if regulating GSK3β activity could weaken cystic TDP-43 intermediate neuroinflammatory in degenerative diseases.

2. Materials and Methods

A. Drosophila stocks All stock flies were raised at 25 °C on standard food. Crosses were performed using a standard procedure and all progeny were raised at 29 °C. The UAS-TDP-43 and the UAS-FUS lines were obtained from Dr. J. Chung. The UAS-TAF15 lines were a gift from Dr. N. Bonini. The alrm-Gal4, the UAS-shaggy RNAi and the UAS-ubiquitin (BL32055) lines were obtained from the Bloomington Drosophila Stock Center. The pan-neuronal driver, elav-Gal4, and the eye-specific driver, GMR-Gal4 lines were also obtained from the Bloomington Drosophila Stock Center. W1118 flies were used as a control.

B. Western blot analysis Protein extracts for western blot analysis were prepared by homogenizing ten 14-day-old male fly heads. The total protein extracts (10 μg) were separated using a 4~12% gradient SDS-PAGE gel and transferred to PVDF membranes (Millipore). The membranes were blocked with tris-buffered saline (TBS) with 4% non-fat dry milk or 4% bovine serum albumin (BSA) for 1 h. The following primary antibodies were used: rabbit anti-TAF15 (1:1000; GeneTex), rabbit anti-Drosophila parkin (1:1000; a gift from Leo Pallanck, University of Washington), mouse anti-ubiquitin (1:1000; Enzo Life Sciences), and rabbit anti-β-actin (1:4000; Cell Signaling). The primary antibodies were detected with the following horseradish peroxidase (HRP)-conjugated secondary antibodies: goat anti-rabbit IgG HRP conjugate, and goat anti-mouse IgG HRP conjugate (1:2000; Millipore). Detection was carried out using an ECL-Plus kit (Amersham).

C. Immunohistochemistry Adult fly brains were dissected from 14-day-old flies and fixed with 4% formaldehyde in a fixative buffer (100 mM PIPES, 1 mM EGTA, 1% Triton X-100, and 2 mM MgSO4, pH 6.9). The brains were then stained overnight at 4 °C with rabbit anti-TDP-43 antibody (1:200; GeneTex). The samples were then incubated with Cy3-conjugated secondary antibodies (1:200; Jackson Immunoresearch) and DAPI (1:500; Sigma-Aldrich). All images were analyzed using a DE/LSM510 NLO Carl Zeiss confocal microscope.

D. In vivo ubiquitination assay Two hundred male fly heads were dissected from 7-day-old flies and homogenized in the IP lysis buffer (50 mM Tris-HCl, 150 mM NaCl, 10% glycerol, 5 mM EDTA, 5 mM EGTA, 0.1% NP-40, and 1× protease inhibitor cocktail, pH8.0) with 50 μM MG132 (Millipore) and centrifuged at 12,000 × g for 30 min at 4 °C. The supernatant was incubated with an anti-TAF15 antibody (3 μg; GeneTex) and then with protein G sepharose (GE Healthcare) for 5 h at 4 °C. Beads were washed five times with PBS and boiled in the SDS sample buffer (Invitrogen).

E Life span and climbing assay Twenty male flies of each genotype were placed into different vials and maintained at 29 °C. On each of the subsequent days, all groups were transferred to fresh vials. The number of dead flies was recorded. Climbing performance was assessed using a negative geotaxis assay. Ten male flies of each age group were anesthetized with CO2 and placed in a column vial. After a 30-min recovery, flies were tapped to the bottom of the column. Flies that climbed to the top of column were counted after 1 min. The assay was repeated four times for each sample of flies at 5 min intervals.

3. Results

3.1. GSK3β / Shaggy enzyme activity was increased in TDP-43-induced drosophila degenerative model

In genetic modifier screening exhibit that neurodegenerative disease-causing genes genetically interact with Shaggy. In comparison with the controls, TDP-43, FUS, TAF15 induced neurodegenerative disease model displayed enhanced rough-eye phenotype. However, co-expression of Shaggy and neurodegenerative disease-causing genes more enhanced rough-eye phenotype but rescued in shaggy RNAi or ShaggyDN co-expression flies.

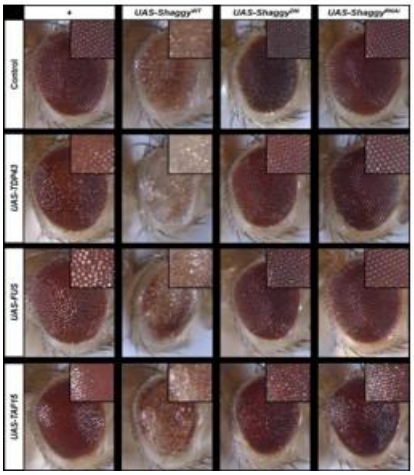

Figure 1. Genetic modifier screen revealed genetic interaction between neurodegenerative diseases causing various genes and GSK3β / Shaggy.

3.2. Inhibition of Shaggy restored the abnormal wing posture in TDP-43-induced drosophila degenerative model

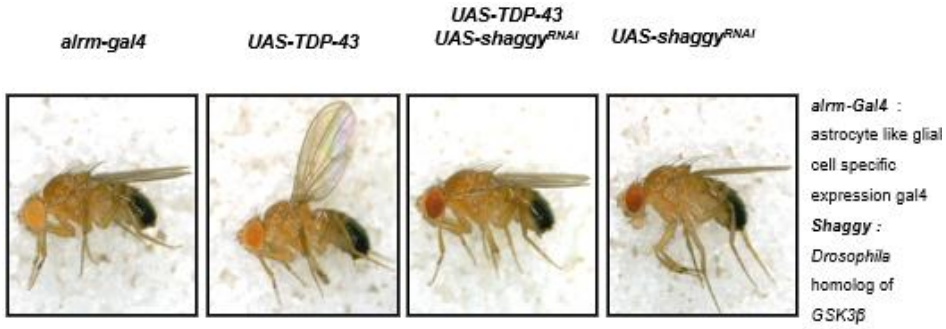

Figure 2. Inhibition of GSK3β restored the abnormal wing posture in TDP-43 induced model.

3.3. Inhibition of Shaggy restored the locomotor activity of adult flies in TDP-43-induced drosophila degenerative model

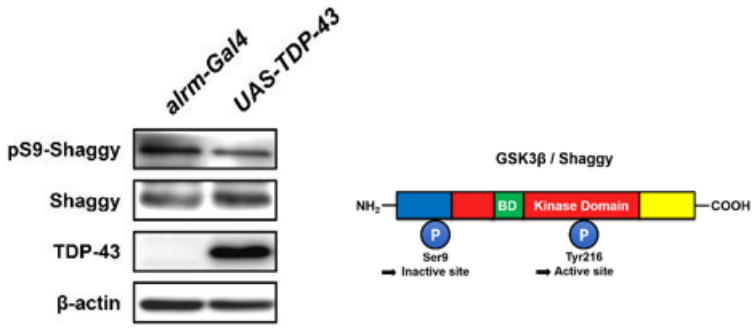

Figure 3. GSK3*β* enzyme activity was increased in TDP-43-induced model.

3.4. Cytoplasmic TDP-43 was decreased by the knockdown of GSK3β

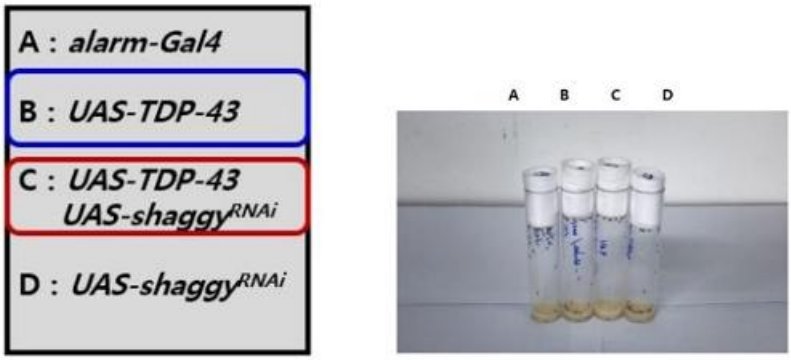

Figure 4. Inhibition of Shaggy restored the locomotor activity of adult flies in TDP-43-induce model.

3.5. Astrocyte-derived TDP43 aggregates are spread and propagation to neurons

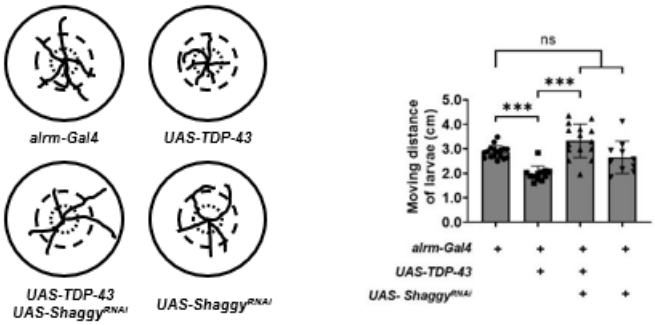

Figure 5. Inhibition of Shaggy restored the locomotor activity of larvae in this model.

3.6. Inhibition of Shaggy in the TDP-43-expressing flies restored the decreased number of boutons and size at the Neuromuscular Junction

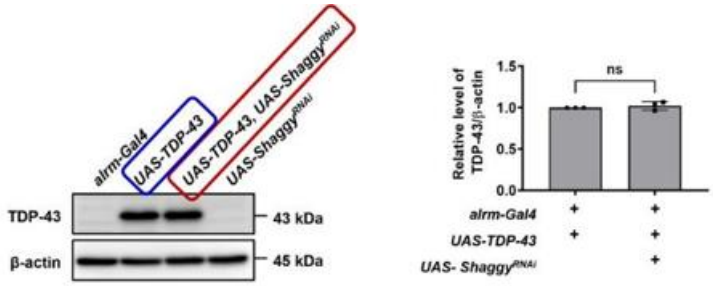

Figure 6. There was no significant difference in the expression level of TDP-43 by shaggy Knock-down.

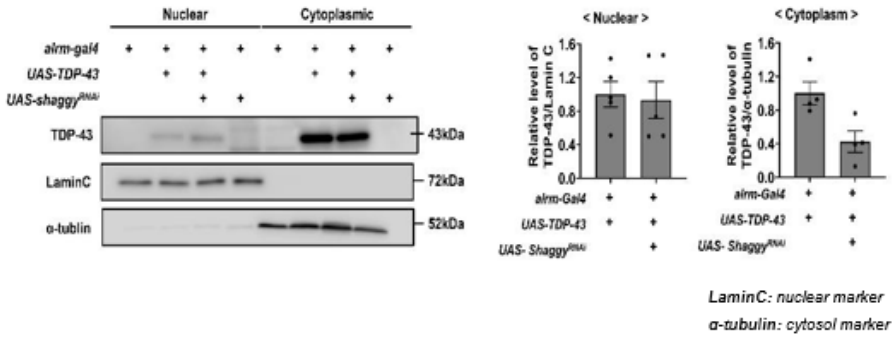

Figure 7. Cytoplasmic TDP-43 was decreased by the knockdown of GSK3β.

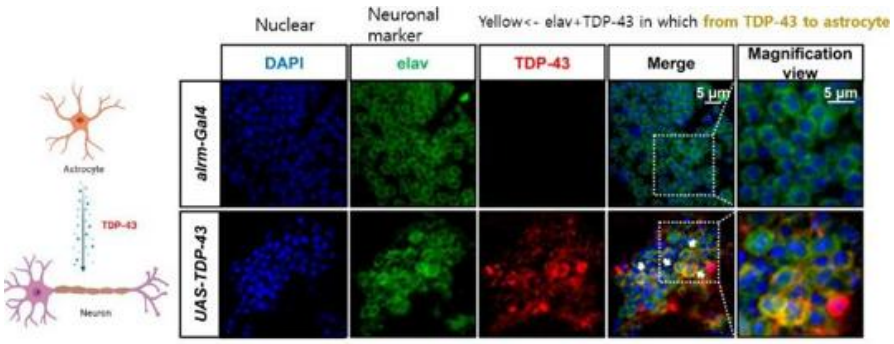

Figure 8. Astrocyte-derived TDP43 aggregates are spread and propagation to neurons.

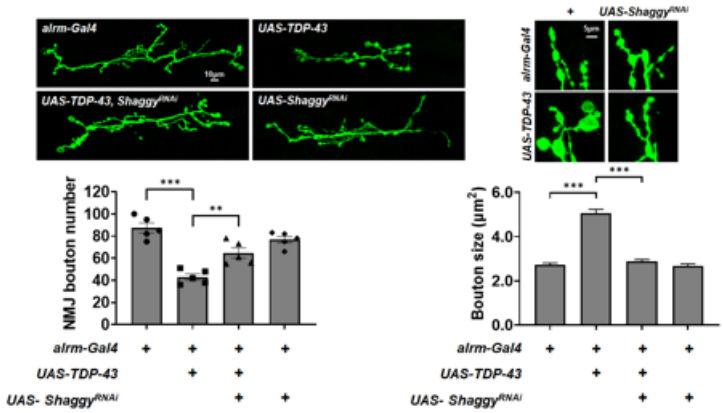

Figure 9. Inhibition of Shaggy in the TDP-43-expressing flies restored the decreased number of boutons.

4. Discussion & Conclusions

In this study, it was to identify the GSK3β to protect neurotoxicity and to further understand the protective mechanism against the TDP-43-induced neurodegenerative disease in Drosophila. GSK3β / Shaggy enzyme activity was increased in TDP-43-induced drosophila neurodegenerative model. Inhibition of GSK3β (GSK3β RNAi) restored the locomotor activity of adult flies in this model. Cytoplasmic TDP-43 was decreased by the knockdown of GSK3β and the astrocyte-derived TDP43 aggregates are spread and propagation to neurons. And finally,

GSK3βi restored the decreased number of boutons and size at the Neuromuscular Junction in the TDP-43-expressing flies. Our study provides the relationship between GSK3β activity and TDP-43 mediated neuritis in neurodegenerative diseases such as ALS or Parkinson's disease.

Author Contributions: Dr. Eu jene Choi performed the literature review, interpreted laboratory results and wrote the first draft of the manuscript. Dr. Kiyoung Kim conceptualized the study, planed the methodology and performed the experiment overall. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

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Background and Therapeutic Implications of Folic Acid Deficiency at a General Hospital in Tokyo

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Abstract: This study is the background, research findings, and clinical implications of folic acid deficiency at a medical institution. Folic acid is vital for DNA synthesis and critical for pregnant women, as deficiency causes megaloblastic anemia and neural tube defects. Long-term deficiency increases risks of cardiovascular disease, dementia, osteoporosis, chronic kidney disease, and macular degeneration. The study analyzed 955 blood samples from January 2022 to February 2025, identifying 52 confirmed folic acid deficiency cases (5%). Deficiencies were notably prevalent among elderly men living alone and women residing in care facilities. Other nutritional deficiencies, like zinc and Vitamin B12, were frequently observed but insufficiently assessed. Treatment strategies included folic acid supplements, yet only half of the cases received appropriate care. High ferritin levels, possibly due to inappropriate iron supplementation for anemia, were also highlighted. The research underscores the urgent need for better nutritional education, proactive monitoring in elderly populations, and careful management to avoid complications, particularly when addressing concurrent deficiencies like Vitamin B12, which if inadequately treated, could exacerbate neurological symptoms.

Keywords: folic acid, nutritional state, elderly's disorder

1. Introduction

Folic acid is a very important nutrient (vitamin) necessary for the synthesis of nucleic acids (components of genetic DNA). It is particularly important for pregnant women, as deficiency can lead to megaloblastic anemia and neural tube defects in the fetus. In general, long-term folate deficiency increases the risk of developing atherosclerosis (stroke, myocardial infarction), dementia, chronic kidney disease, osteoporosis, and age-related macular degeneration, as well as the risk of requiring long-term care.

Over 94 countries worldwide have implemented folate fortification programs. In countries such as the United States and Canada, folate fortification in grains is mandated by law.

In Japan, as long as people consume traditional Japanese cuisine, deficiency is rare, and therefore, little attention is paid to this nutrient.

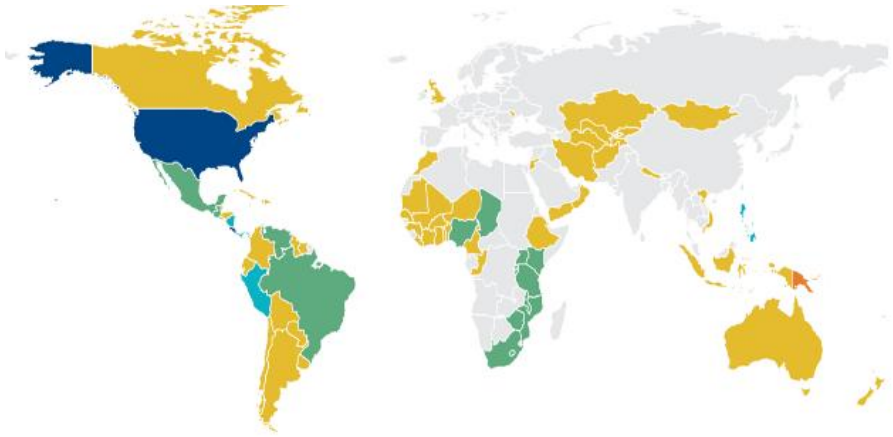

Figure 1. Countries other than those in white have implemented folate fortification in some form [1,2].

Folate supplementation for pregnant women is recommended through the distribution of leaflets. (In Cambodia, folic acid and iron supplements for pregnant women are available.)
Due to the rapid changes in Japanese society, the quality of traditional Japanese diets has declined, and we suspect that deficiency is becoming a serious problem among people living alone and elderly couples [2,3].

2. Materials and Methods

Between January 2022 and February 2025, we examined 955 samples for folic acid levels in the blood at our hospital. Among these, 142 individuals (15% of all samples) had folate levels between 2.0 ng/ml and 3.9 ng/ml, indicating suspected deficiency, and 52 individuals (5%) had levels below 2.0 ng/ml, diagnosed as folate deficiency. To diagnose suspected cases, it was necessary to measure homocysteine, which is metabolized slowly in cases of folate deficiency, but this was rarely performed at our hospital.

Therefore, we conducted a survey of the 52 individuals diagnosed with folate deficiency based on their folate levels alone, using information from their medical records regarding their living environment, family structure, other nutritional test items, and measures taken to address folate deficiency.

3. Results

3.1. Living environment and family composition of 52 individuals; 22 males, 30 females

① Living alone ; 15 males, 5 females, total 20

② Residing in a nursing home or similar facility; 12 females, 2 males, total 14
Breakdown of nursing homes
A: 2, B: 2, C: 2, D: 1, E: 1, F: 1, G: 2, H: 1, I: 2

③ Living with two people ; 9 females, 4 males, total 13

④ Living with three or more people ; 4 females, 1 male, total 5

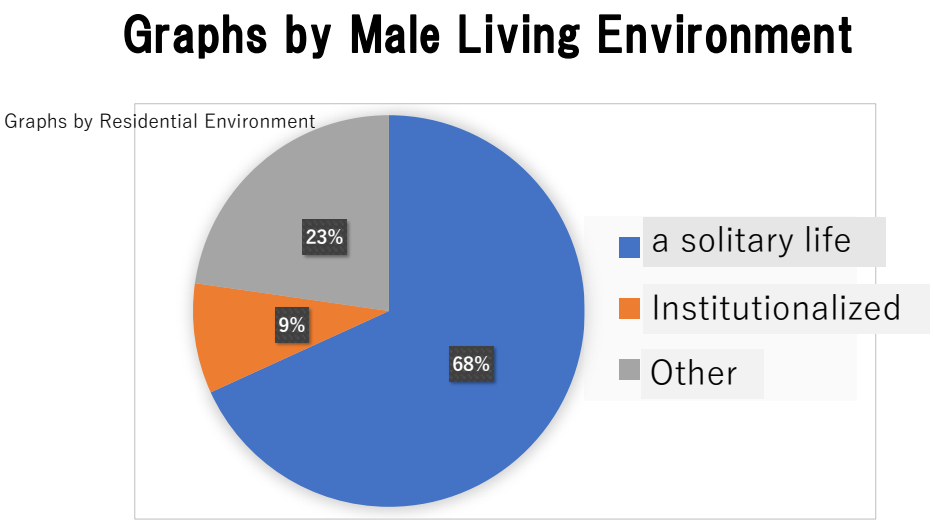

Figure 2. Graph by Male Residential Environment.

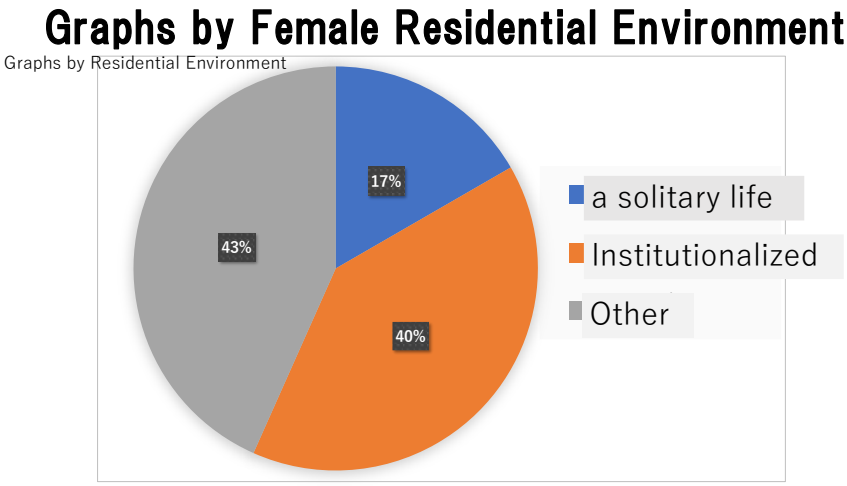

Figure 3. Graph by Female Residential Environment.

3.2. Abnormalities in other nutritional indicators

① Moderate or severe zinc deficiency: 18 (35%)

② Elevated ferritin levels: 16 (31%)

③ Low ferritin levels: 3

⑤ Vitamin B12 deficiency: 4 (many not tested)

⑥ Elevated homocysteine levels: 1 (many not tested)

3.3. Prescriptions, etc. [3]

① Oral administration of folic acid tablets; 23

② High-calorie intravenous infusion (containing folic acid); 4

③ This survey did not investigate whether nutritional guidance or other measures were taken, as indicated in the medical records.

4. Discussion

There were more single men than women. It is possible that women eat a more balanced diet. The deficiency was common among women residing in facilities, but it was distributed relatively evenly across facilities, suggesting that it may be a broader issue for such facilities. However, some individuals with deficiency were also found among those living with family members due to various circumstances. Additionally, many individuals were found to have zinc deficiency, which can indicate mineral intake deficiency, suggesting that there may be a general lack of adequate nutrient intake. Elevated ferritin levels were a cause for concern, as they may indicate iron deficiency anemia, which is treated with iron supplements. At our hospital, there were cases where iron supplements were administered for anemia without closely monitoring ferritin levels. The fact that vitamin B12 and homocysteine levels were rarely checked in individuals with folate deficiency at our hospital was identified as a significant issue.

Furthermore, the fact that folate deficiency treatment is only prescribed to half of the patients is an issue that needs to be addressed in the future.

5. Conclusions

As expected from the outset, folate deficiency was common among single men. In addition to nutritional guidance, the hospital should take a comprehensive approach to improve the diet and overall lifestyle of these individuals.

At the same time, folate deficiency was also common among women residing in facilities. It may be advisable to provide this information to nearby facilities and suggest ways to improve nutritional intake.

When treating patients, it may be necessary to educate physicians about the potential worsening of neurological symptoms associated with prior or sole administration of folic acid in cases of vitamin B12 deficiency.

Conflicts of Interest: The authors declare no conflict of interest.

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The Special Nature of the Navel and the Fontanelle

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Abstract: According to Reverend Moon, "Humans pass through three stages of existence: the aquatic stage in the womb, the terrestrial stage on Earth, and the aerial stage in the heavens. The fetus in the womb receives nutrients through the navel. The navel is the mouth of the fetus." In this sense, the navel can be considered the mouth of the past. For humans who have left the womb, the navel is merely a trace of the past and is not considered to have any special role. However, in Oriental Medicine the navel is called Shenque and is regarded as the place where the divine resides. Through treatments using the navel, the uniqueness of the Shenque has been examined. Additionally, Reverend Moon is said to have stated, "When humans enter the spirit world, they begin to breathe through the fontanelle on top of their heads and through their cells. The air in the spirit world is not the air of the Earth but love." The fontanelle on top of the head refer to the Baihui. Through treatment using the Baihui, we have examined its special nature. From the perspective of Oriental Medicine, we have examined these two acupoints and compared them.

Keywords: navel, Shenque, fontanelle, Baihui

1. Introduction

The gateways that divide the three stages of human life, as described by Reverend Moon, are birth and death [1]. These are the most important and solemn moments in human life. While childbirth is now safely performed in hospitals, in the past, both mothers and children risked their lives during delivery. And death, of course, is a major issue concerning life. Understanding birth and death greatly influences a person's perspective on life.

Nevertheless, scientific research on death in particular has not advanced significantly, and religious scholars have proposed a wide range of theories. In Oriental Medicine, it is believed that treatment should not be administered to seriously ill patients with no hope of recovery. As a result, there has been little research on death itself in Oriental Medicine. Classical texts cite various theories from Buddhism and Taoism [2], but they cannot be said to be connected to clinical practice.

Therefore, in this paper, in order to clarify the two gateways of birth and death, I will discuss two acupoints—Shenque and Baihui—and present clinical examples.

2. About the Shenque

Human life undergoes significant changes before and after birth. Before birth, the fetus lives in amniotic fluid, and the navel functions as its mouth. After birth, this role shifts to the mouth. The lungs begin to function, and with that, the lung meridian starts to circulate. The newborn begins to breastfeed through the mouth, and digestive activity in the stomach and intestines commences. At the same time, the arteries and veins connected to the navel cease to function and begin to atrophy.

In modern medicine, the umbilicus after birth does not appear to hold much clinical significance. However, from the perspective of Oriental Medicine, it serves the following functions.

2.1. The Role of the Navel

2.1.1. The Center of the Body

The vascular system of the navel degenerates and disappears after birth. However, unlike a surgical scar, the navel does not vanish; it remains at the center of the abdomen. It serves as a central reference point, defining the positional relationship between the upper and lower, and left and right sides of the body. The location of qi around the navel is an important factor in evaluating a person's health.

2.1.2. Function as the Origin

When the embryo implants in the uterus, the navel begins to form from that central point. Using the navel as the origin, coordinate axes are established, and surrounding cells begin to differentiate based on their relative position. All cellular growth and development proceed with the navel as their point of origin.

2.1.3. Role as a Compass

By gently palpating the area around the navel, one can distinguish between regions of hardness and tension versus softness and weakness. Areas of hardness are referred to as excess, while soft areas indicate deficiency. The pattern of deficiency and excess around the navel reflects the overall energetic balance throughout the body. Just as a compass point north, the navel reveals areas of energetic imbalance. [3]

Case Study: A 70-year-old woman presented with chronic right shoulder pain. Conventional acupuncture applied to the right flank proved ineffective. Upon examination of the navel, tension was discovered on the left side. Acupuncture administered to the hardened area on the left flank resulted in improvement, suggesting a systemic relationship mediated through the navel.

2.1.4. As Shenque

In Oriental Medicine, the navel is known as Shenque, meaning "the palace of the gods," or a place of spirit and life. It is regarded as a highly significant acupoint in terms of energy dynamics within the body. Although it is not a location where energy flow is easily sensed, it is considered a vital reservoir of stored energy.

2.1.5. Center of the Ren Meridian

Located along the center of the Ren Meridian (Conception Vessel), Shenque is pivotal for activating this meridian. Stimulating Shenque is believed to replenish qi, dispel cold, regulate digestion, and promote recovery.

2.2 The Importance of the Navel in Classical Texts

The following three passages are found in Shindo Hikketsu Shu [2], a representative secret text of the Mubunryu school [4].

1. When various treatments are ineffective, apply acupuncture to the Shenque point.

2. The navel governs the entire body. The Shenque point is the Sansho Fu. To determine the prognosis of a seriously ill patient, examine the artery at the Shenque point.

3. First, examine the artery at the Shenque point. If there is no pulse, there is no point in performing acupuncture. If there is even the slightest pulse, perform deep acupuncture on both sides of the sternum. If this does not work, perform deep acupuncture at the Shenque point. If that still does not work, accept it as fate.

2.3 The Treatment Method of Tapping the Navel

Rev. Moon says, “Say, ‘Navel, you've had a hard time in the past,’ and touch it. If you tap the navel a lot, you will become healthy [1].” We verified the effects of stimulating the navel.

2.3.1. Method

The patient's navel was tapped 100 times, and pulse diagnosis and abdominal diagnosis were performed before and after. In addition, changes in physical and mental symptoms were observed and interviews were conducted.

In case 4, acupuncture was performed instead of tapping.

2.3.2. Case reports

Case 1: 59-year-old male

Saying, “Navel, you have suffered in the past,” the navel was lightly tapped 100 times with the fingertips.

Spleen deficiency pulse → normal pulse. Large spleen pain 10 cm → spleen pain 3 cm.
The area around the navel seemed to become active. Seven hours later, the patient experienced abdominal pain and diarrhea. The next morning, the patient felt a sense of security, as if the umbilical cord were connected to the cosmic mother.
Repeated the procedure the following days, but no diarrhea or abdominal pain occurred. The spleen pain decreased.

Case 2: 93-year-old woman
Saying, "Navel, you've had a hard life," and lightly tapped the navel 100 times with the fingertips.
Spleen deficiency pulse → normal pulse
She said that scenes from her past memories spread before her eyes. Her speech became clearer. Her expression brightened.
When I examined her again five days later, her speech and expression had returned to normal. Her pulse was also spleen deficient. The same treatment improved her condition.

Case 3: 29-year-old male with hypersensitivity
I had him gently tap his navel himself and asked for his impressions.
: Improved moisture in the swollen navel. Slight improvement in mother-child relationship. Improved irritability. Improved intestinal discomfort. The vibrations directly transmitted to the intestines felt pleasant.
Emotional maternal personality recovered. Motivation to do tasks like cleaning, which he usually hesitates to do, increased. Improved summer fatigue and increased appetite. Relaxation effect. Natural sleepiness.

Case 4: 59-year-old male, shingles on left leg, spleen deficiency pulse
Hard navel, abdominal diagnosis: extensive hardness around the stomach. Acupuncture on the hard navel reduced pain in the leg.

Case 5: 51-year-old male with shingles on the left side of the abdomen.
The right side of the abdomen feels cold, liver deficiency pulse. Acupuncture on the hardened area of the navel relieved the hardened area of the thigh. The temperature difference between the left and right sides also decreased.

Case 6: 57-year-old male, diabetes taking insulin, Irritated and overeating during hypoglycemia. Spleen deficiency pulse. Abdominal examination: The left hypochondrium is stiff. Acupuncture in the Dadu SP2 can compensate for spleen deficiency. Furthermore, when I lightly tapped navel with fingers 100 times, the pulse became straight and energetic.

2.3.3. Results

ON 30 cases

Table 1. Results of the Treatment of Tapping the Navel

diagnosis		cases
Pulse diagnosis	In order	17
	Somewhat in order	13
	unchanged	0
Abdominal diagnosis	Induration no longer	1
	Partially improved	25
	unchanged	4
symptoms	Improved even a little	25
	Unchanged or unknown	5

2.3.4. Results

Lightly tapping and stimulating the navel relaxes the gastrointestinal tract. Continuing this daily may help maintain a balanced qi state, potentially leading to symptom improvement and preventive effects.

Additionally, understanding the navel's past functions can help affirm the past and foster gratitude toward parents, improving parent-child relationships. Recognizing that one is connected rather than alone may reduce feelings of loneliness.

The navel may store memories from when it was connected to the mother. Tapping the navel may evoke these memories, potentially making it effective for psychotherapy.

Since the navel was an organ that connected to the mother, it may be easier to feel motherhood, peace, love, and tranquility, such as the mother of the universe. By tapping the navel and concentrating qi, blood, and consciousness on the navel, and imagining the umbilical cord connecting to the mother of the universe, further psychological and spiritual effects can be expected.

As in case 6, diabetic patients develop spleen deficiency. By hitting the navel, the spleen meridian was replenished. The spleen meridian is a meridian that nourishes the pancreas, so if you continuously tap the navel, it is expected that the function of the pancreas will improve. 4. Discussion

Lightly tapping and stimulating the navel relaxes the gastrointestinal tract. Continuing this daily may help maintain a balanced qi state, potentially leading to symptom improvement and preventive effects.

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3. About the Baihui

In Indian yoga, the seventh chakra is the highest chakra. This corresponds to the Baihui point in Oriental Medicine. It serves the role of unifying with the divine and the universe.

Rev. Moon states that in the spirit world, breathing occurs through the Baihui point and cells. This Baihui point also functions as the mouth for communicating with the spirit world.

The Baihui point is important not only after death but also in this world, where we prepare for life in the spirit world. This is because we prepare to breathe spiritual love through the Baihui point as the mouth.

3.1 The Importance of the Baihui in Classical Texts

1. The meeting place of the hundred meridians (shinkyukouotukyo) [5].
2. The place where the Yang meet (shinkyutaisei) Ming [6].
3. Du Mai is the meeting place of every Yang. Baihui is that total meeting place (ruikyo) [7].
4. The Baihui is the place where the qi of the Yang meridian of the whole body gathers. It connects with the heaven. He receives the energy of heaven from Baihui (Huangdi Neijing) [8].

In Taoism, it is said that human communicate with heaven through the top of their heads. The Baihui has become a place for spiritual exchange and serves as a spiritual mouth. Although it varies depending on religion and culture, it is thought that the Fontanelle, the Baihui point and the seventh chakra on the top of the head are the spiritual mouth.

3.2 Cases using the Baihui

Case 7: 44-year-old female with uterine fibroids, pain in the back of the legs, and headaches

Treatment was performed on the stomach, liver, and bladder meridians. The distended abdomen relaxed, and the headaches were alleviated. When standing up, there was pain in the soles of the feet and the back of the legs. Acupuncture was performed on Baihui, which alleviated the pain.

Case 8: 44-year-old male with pain in the right shoulder and neck, and eye strain
The pulse indicated liver deficiency. Low-frequency electrical therapy was applied around the surgical scar on the right lower abdomen. Treatment of the Liver Meridian was performed throughout the body. Pain remained on the right side of the seventh cervical vertebra. Acupuncture at the Baihui point alleviated the pain.

Case 9: 26-year-old male, eye strain from excessive PC use, shoulder stiffness
The pulse indicated liver and kidney deficiency. Treatment of the Liver Meridian and Kidney Meridian was performed. Finally, acupuncture was applied to the Baihui point, and the patient reported a sensation of relief from the head, with the heavy feeling in the head being alleviated.

Case 10: 29-year-old female, shoulder stiffness, neck stiffness, bipolar disorder
Treatment was primarily focused on the spleen meridian and stomach meridian to promote relaxation, and the shoulder stiffness improved. However, a sense of discomfort remained in the upper cervical spine. Acupuncture was then applied to the Baihui point, and the discomfort disappeared.

3.3 Consideration

Since the Baihui point is connected to all 100 meridians, it has a wide range of effects.
It not only affects physical symptoms such as pain, but also has an effect on the psychological aspect.

When acupuncture is performed on the Baihui, it is easy to get the effect if you are conscious of bringing in the qi of heaven from there and directing the qi to the affected area. It is very effective if you are conscious of descending from the Baihui through the brain to the Perineum. And the qi that came out of the Perineum went up through the Ren and Du meridians towards Baihui. You can use this circulation to clean the stagnation of qi in the body.

In Case 7, a woman with uterine fibroids had acupuncture at the Baihui point to introduce energy, and by expelling pathogenic energy from the Perineum, the abdomen with the fibroid became softer.

In Case 8, a man with eye strain had energy introduced from the Baihui point, which was then guided through the eyeball, optic nerve, and thalamus area to flush out impurities, alleviating the eye strain.

Conversely, in Case 9, there are cases where one feels the evil energy being expelled from the Baihui point.

How the Baihui point functions after a person dies and enters the spirit world remains unverified. However, through clinical cases, it has been confirmed that the spiritual body, which coexists with the physical body in this world, uses the Baihui point as an entrance to receive celestial energy and circulate it.

4. Discussion

The Governor Vessel, Du Mai where the Baihui point is located, rises from the Perineum point, passes through the Baihui point at the top of the head, and reaches the Yingjiao GV28 point. The Conception Vessel, Ren Mai where the Shenque point is located, rises from the Perineum point, passes through the Shenque point, and reaches the Chengjiang CV24 point. Both Yingjiao GV28 and Chengjiang CV24 are acupoints in the mouth. It is interesting that the mouth in this world is the end point of the Conception Vessel and the Governor Vessel. Those whose qi is concentrated in the mouth of this world are likely to place value on material things. Those whose qi is concentrated in Baihui rather than the mouth of this world are likely to place greater value on spiritual love. They may be considered to be prepared for breathing after death.

In this world, the mouth is very important, and the health of the mouth depends on what comes and goes from it. It is very important for diabetics to control their mouths. At the same time, it is important to be aware of the mouth of the past, the Shenque, and the mouth of the future, the Baihui.

The normal appearance of the navel without stimulation is static, and it is only through stimulation that it becomes activated and produces effects.

In Indian yoga, the third chakra is located above the navel and the second chakra is located below the navel, but these correspond to different acupoints called Zhongwan CV12 and Guanyuan CV4, respectively, and are not Shenque itself. Yoga seems to downplay the Shenque point.
The acupuncture meridians end there, but actually qi passes through the body from the mouth to the Perineum point.
Just as the human body is prepared within the womb, the spiritual body is prepared within the physical body.

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Plenary Talks

Artificial Intelligence in Radiology: Transforming Diagnosis and Beyond

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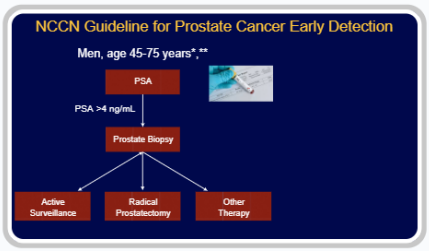

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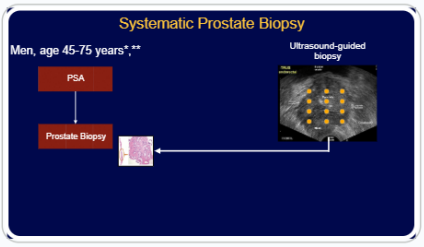

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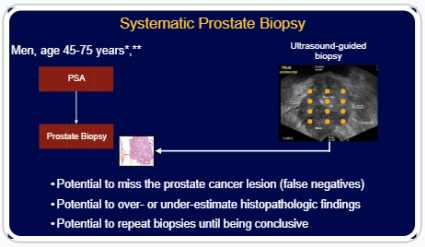

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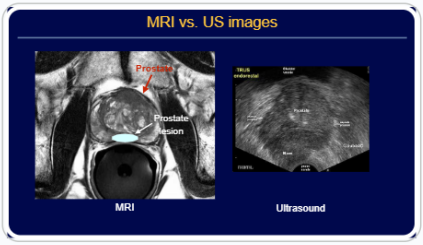

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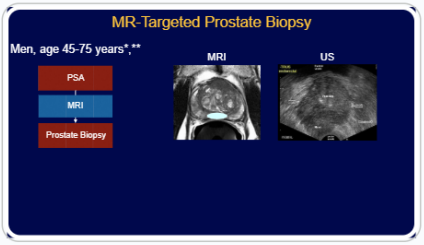

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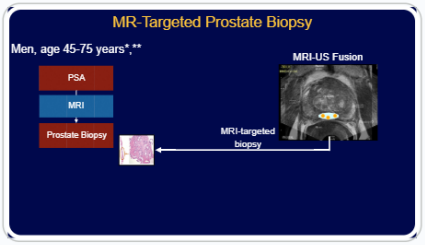

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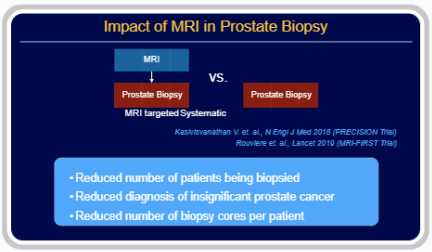

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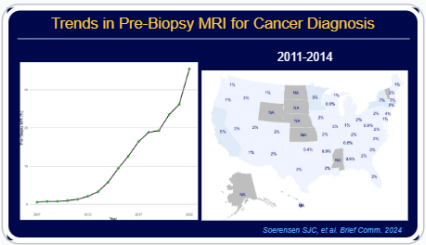

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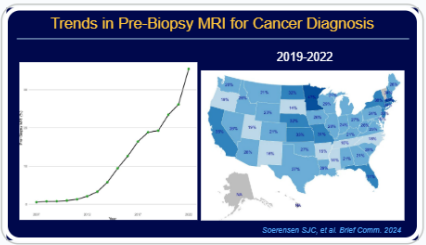

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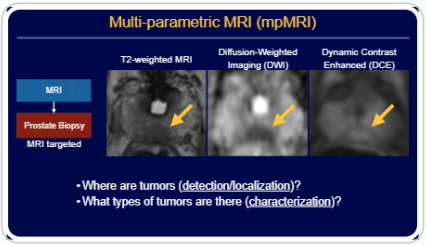

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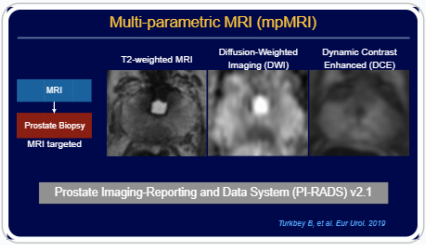

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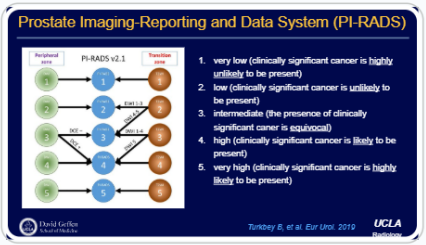

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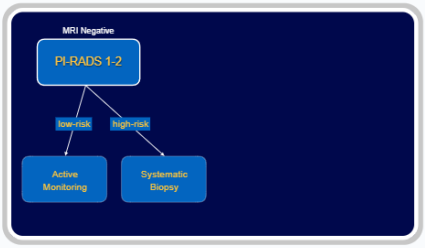

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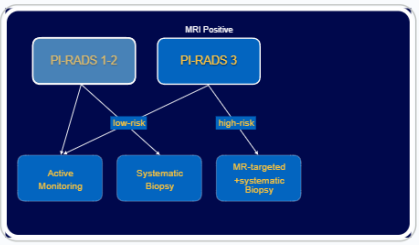

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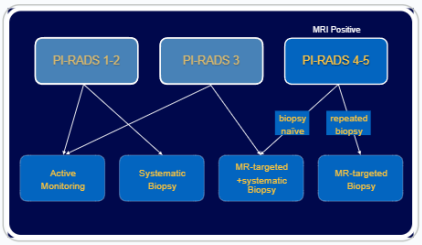

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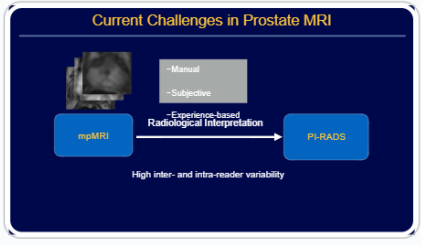

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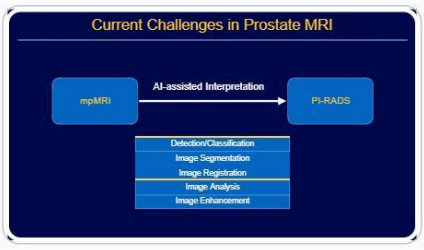

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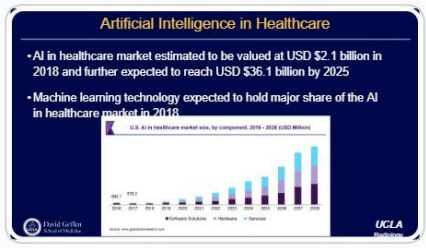

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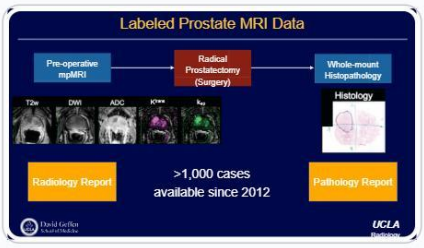

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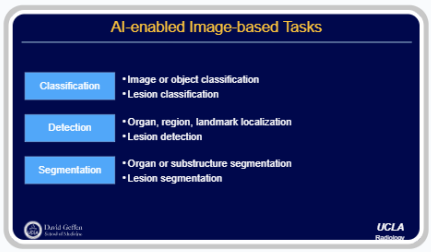

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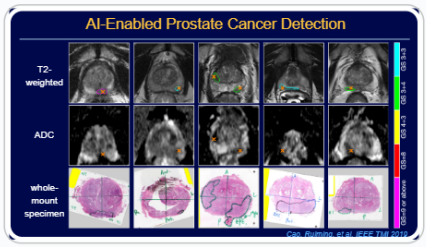

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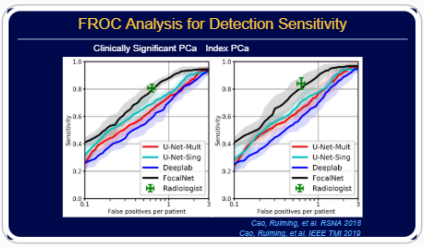

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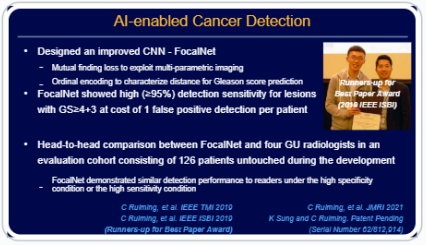

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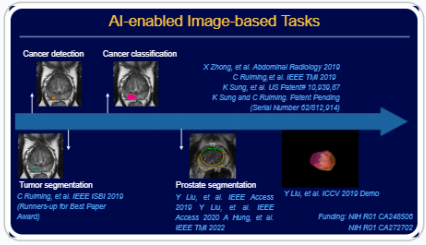

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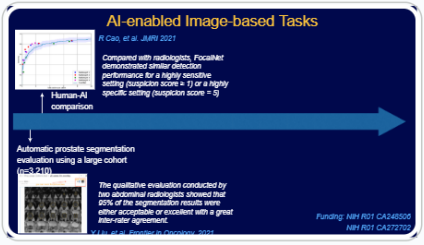

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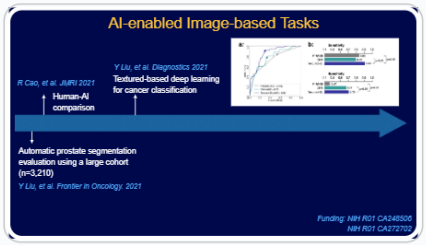

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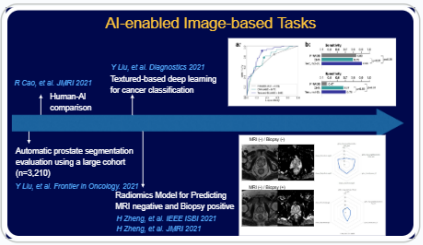

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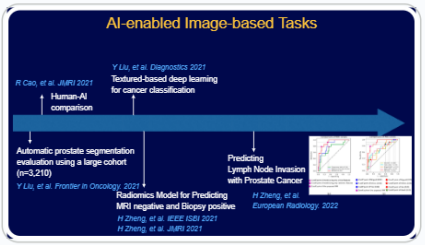

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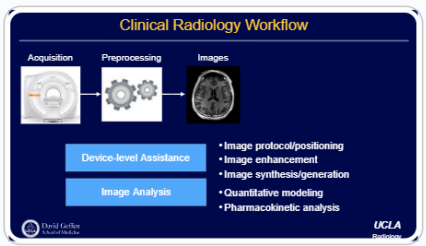

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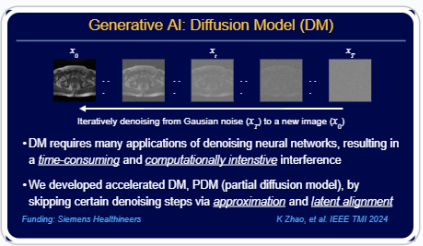

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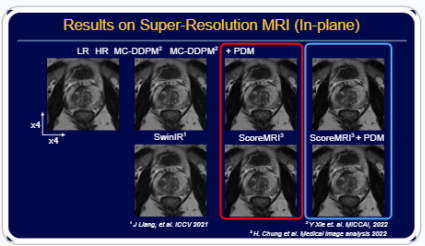

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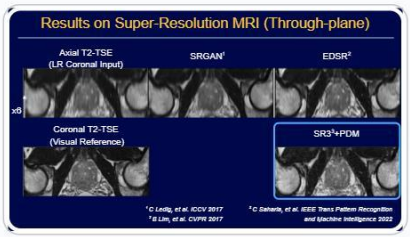

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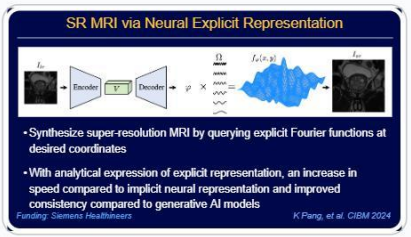

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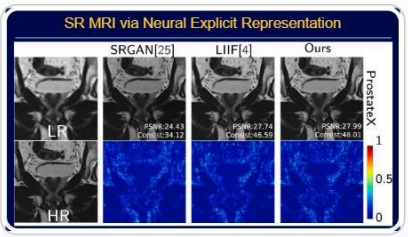

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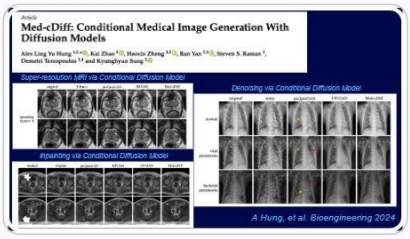

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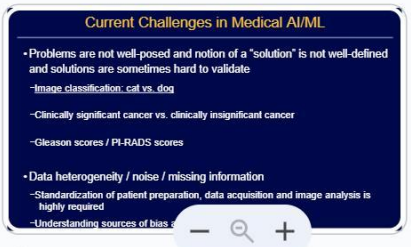

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