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# Integrating Ultrasonic Sound Technology for Wild Boar Deterrence in Agriculture: A Comprehensive Research Analysis

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## Abstract

The proposed approach incorporates an irregular pattern of sound emission, coupled with the inclusion of night-time lights to deter wild boars during nocturnal foraging. This innovative strategy aims to prevent habituation by varying the timing and duration of sound emissions, creating a dynamic and unpredictable deterrent. The ultrasonic sound waves encompass efficacy, humane treatment of wildlife, environmental friendliness, minimal human disturbance, long-term sustainability and adaptability to diverse agricultural landscapes.

## 1. Introduction

In this paper technological implementation of ultrasonic sound as a wild animal deterrent especially wild boars are discussed. It underscores the simplicity and effectiveness of ultrasonic sound devices. Engineered to be lightweight, compact and easy to install, these devices can be strategically positioned around agricultural fields. The adaptability of the technology to varying landscape layouts and its minimal power requirements, typically relying on battery or solar power sources, ensure seamless integration into existing agricultural practices.

Wildlife damage to agricultural crops is a significant concern for farmers worldwide.
While various species of vertebrates, such as birds and mammals, have been implicated in causing damage to agricultural resources, wild boars have become a particularly problematic species in several regions. These animals are known for their destructive feeding habits, habitat destruction and potential for spreading diseases to livestock [1]. Additionally, wild boars are highly adaptable and intelligent, making them difficult to control using traditional methods such as fencing or trapping [2]. The Problem of Wild Boar Damage Wild boar damage to crops poses a significant economic and ecological problem for farmers [3]. Despite various management practices and control efforts, the damage caused by wild boars continues to increase [4]. According to research, damage events involving wild boars mainly occur in vineyards, meadows and oat fields, with a peak incidence in summer and autumn [5]. Farmers in Samsun, Turkey, have reported high intensity damage to crops in areas close to woodland areas due to wild boar activity. Current Methods of Wild Boar Deterrence Current methods of wild boar deterrence include the use of physical barriers like fences, noise deterrents such as scare devices or gunfire and chemical repellents. However, these methods have proven to be ineffective in completely deterring wild boars and preventing crop damage. The Intelligent Deterrent System is needed because the current methods of wild boar deterrence are not sufficient in preventing crop damage caused by these animals. The lack of automation and technological intervention in the agriculture industry has hindered the development of effective deterrent systems. Farmers and crop field owners need a more feasible and efficient solution to protect their crops from wild boar trespassing [6]. The solution Proposed is Intelligent Wildlife Deterrent System To address the issue of wild boar damage to agricultural crops, a proposed solution is the development of an intelligent wildlife deterrent system

This research paper proposes the implementation of an intelligent system as a sustainable technological solution to prevent crop damage caused by wild animal attacks. The system aims to deter wild boars and similar animals from entering farm boundaries through the use of an intrusion detection system installed at the perimeter. The intrusion detection system consists of nodes fixed at the boundary of the farm, which detect animal entry and send this information to a central base station [7-9].

Wild boar deterrents can be used to protect crops and livestock by implementing various strategies. One approach is the use of wild animal repellent devices that utilise LED lights and sounds to drive out wild animals, including wild boars [10]. These devices can be enhanced by incorporating deep learning-based intelligent systems that can accurately determine whether the detected animal is a wild boar or not, allowing for targeted repelling actions [11]. Another method involves evaluating landscape patterns of wild boar dam-

age to identify high-risk areas and implementing mitigation measures such as electric fencing, dissuasive feeding and repelling actions [12]. Random sounds and the use of YOLO V4, a deep learning model that can recognize motion and pattern of animal movement can help address the problems of adaptation and distinction in existing repelling systems [13].

### 1.1. Case Study

Case studies from regions in Mawal taluka in district of Pune, where bamboo and rice are cultivated on a large scale saw a great number of wild boar attacks on the rice fields. Here, according to people almost 30% of the crop is damaged by the wild boars in the surrounding areas of the taluka. In the village of Nigde in the same taluka an experiment was conducted by playing the sound of dogs on large speakers in the field and the crop damage was reduced to a great extent. This exemplifies the tangible benefits of ultrasonic sound technology, showcasing a significant reduction in wild boar-related crop damage and subsequent improvements in agricultural productivity and even not disturbing the people living in the vicinity. This comparative analysis highlights the advantages of ultrasonic technology over traditional methods, emphasising targeted deterrence without disrupting local ecosystems or causing harm to non-target species.

An in-depth cost-benefit analysis reveals the financial and economic viability of implementing ultrasonic technology. While an initial investment is required, the potential economic gains resulting from reduced crop damage and increased agricultural productivity outweigh these costs over time. This strategic allocation of resources serves as a sound financial decision for farmers and land managers. Ongoing research and development efforts play a pivotal role in enhancing the effectiveness of ultrasonic sound wave technology. Researchers focus on optimising factors such as sound frequency, amplitude modulation and emission patterns to maximise deterrence while minimising the risk of habituation. Collaborations between wildlife experts, acoustic engineers and behavioural scientists contribute to a deeper understanding of wild boar sensory perception, informing best practices for farmers and land managers.

### 1.2. Literature Review

The increasing encounters between wild boars (Sus scrofa) and human communities have prompted the exploration of diverse methods to effectively deter these animals, mitigating the damage they inflict on crops and the potential threats they pose to human safety. This literature review critically examines various strategies employed for wild boar deterrence, shedding light on their efficacy, limitations and implications for sustainable coexistence.

Fencing: Fencing emerges as a primary and widely adopted method for mitigating wild boar incursions. The literature underscores the importance of constructing robust barriers, at least four feet in height and securely anchored to the ground. Electric fencing is particularly highlighted for its success in delivering a mild shock upon contact, providing an additional layer of deterrence. However, scholars caution that adaptation by wild boars, such as rooting under barriers, necessitates ongoing innovation in fencing designs.

Trapping: The literature extensively explores trapping as a nuanced approach to managing wild boar populations. Box traps and corral traps, baited strategically, emerge as effective tools for capturing boars. However, scholars emphasise the need for expert handling to prevent unintended consequences and ensure humane treatment of captured animals. Ethical considerations surrounding relocation practices and the potential stress inflicted on trapped boars underscore the complexity of this method.

Repellents and Scare Tactics: Chemical repellents and scare tactics represent a multifaceted approach to wild boar deterrence. Repellents, when applied to crops or specific areas, exploit aversive odors or tastes to dissuade boar activity. Scare tactics, involving noise-making devices, bright lights and even trained dogs, offer short-term efficacy. However, the literature cautions that sustained exposure may lead to habituation, diminishing the long-term effectiveness of these methods.

Guard Animals: Deploying guard animals, notably dogs and donkeys, is examined as a dynamic and living deterrent strategy. The literature underscores the importance of canine breeds with herding instincts and the territorial nature of donkeys in deterring wild boars. While promising, scholars advocate for thorough training and careful integration with existing livestock to maximise effectiveness without compromising animal welfare.

Hunting and Culling: Controlled hunting and culling programs are investigated as means of managing wild boar populations. Licensed hunters play a pivotal role in harvesting a predetermined number of boars within designated areas. The literature emphasises the necessity for stringent regulation to prevent overhunting, ensuring ecological balance. Ethical considerations surrounding humane culling practices and the potential impact on population dynamics are central themes in this discourse.

Food Source Management: The review highlights the significance of addressing the root cause of wild boar attraction – abundant food sources. Proper waste disposal, securing livestock feed and protecting crops are identified as integral components of a holistic deterrence strategy. The literature underscores the importance of community engagement in implementing sustainable food source management practices.

Sonic Deterrents: Sonic deterrents, leveraging loud noises or ultrasound frequencies, are explored as potential tools for creating discomfort in wild boars. The literature acknowledges the efficacy of such devices in the short term but underscores the risk of habituation over time. Ongoing research is encouraged to refine sonic deterrent technologies and address the evolving behaviours of wild boar populations.

Natural Barriers: Creating natural barriers, such as ditches or water bodies, is examined as an ecological approach to

impeding wild boar movement. While water barriers demonstrate efficacy, the literature highlights the need for strategic landscape planning to optimise the effectiveness of natural barriers. Scholars advocate for a nuanced understanding of boar behaviour and terrain characteristics for successful implementation.

This comprehensive literature review elucidates the intricate landscape of wild boar deterrence methods, emphasising the need for integrated and context-specific strategies. As human-wildlife interactions continue to evolve, ongoing research, community engagement and interdisciplinary collaboration are underscored as critical elements in developing sustainable and humane solutions to foster harmonious coexistence between humans and wild boars [Traditional Methods] https://doi.org/10.22271/tpi.2022.v11.i7Se.13673.

### 1.3. Research and Development

Ongoing research and development efforts play a pivotal role in enhancing the effectiveness of ultrasonic sound wave technology for wild boar deterrence. This section explores the current state of research, recent advancements and future directions in the development of ultrasonic technology to address the challenges posed by wild boar attacks on agricultural fields.

Optimising Sound Frequency and Modulation: Central to the research endeavours is the optimization of sound frequency, amplitude modulation and patterns of sound emission to maximise the deterrent effect while minimising the potential for wild boars to habituate to the sound over time. Researchers have been conducting experiments to identify the most effective configurations, considering factors such as the hearing range of wild boars, their adaptability and the irregular patterns that can prevent habituation. This fine-tuning process aims to create a deterrence mechanism that remains consistently effective in deterring wild boars from entering cultivated areas.

Field Experiments and Deployment Strategies: Field experiments are essential to validate the efficacy of ultrasonic sound wave technology in real-world conditions. Researchers have been actively conducting experiments across diverse agricultural landscapes to understand how ultrasonic devices perform in varying terrains, weather conditions and vegetation types. The insights gained from these experiments inform the development of best practices for deploying ultrasonic technology. This includes strategic placement of devices, considering terrain variations, vegetation interference and potential obstacles, ensuring comprehensive coverage of target areas.

Behavioral Studies and Sensory Perception: Understanding wild boar behaviour and sensory perception is a crucial aspect of research and development. Behavioural studies provide insights into how wild boars respond to ultrasonic sound waves and how they may adapt over time. Researchers collaborate with behavioural scientists to delve into the intricate details of wild boar habits, enabling the refinement of ultrasonic technology. By gaining a deeper understanding of wild boar sensory perception, researchers can optimise the technology to create deterrent mechanisms that effectively address the dynamic nature of wild boar behaviour.

Power Consumption and Maintenance: Research efforts also concentrate on minimising power consumption and developing low-maintenance devices. Ultrasonic devices typically rely on battery or solar power sources and ongoing studies explore ways to optimise energy efficiency. Researchers develop routine maintenance protocols to ensure the continuous functionality of devices, including checks for device functionality and battery health. The goal is to create a system that requires minimal intervention, reducing operational costs and enhancing the long-term sustainability of ultrasonic sound wave technology.

Integration of Data Analytics and Predictive Modeling: Recent advancements include the integration of data analytics and predictive modelling to enhance the precision of device placement and deployment strategies. Researchers explore the potential of data-driven approaches to predict wild boar behaviour based on various factors such as weather conditions, seasonal variations and historical data. This data-driven approach aims to optimise the placement of ultrasonic devices, ensuring strategic coverage and maximising the effectiveness of deterrence efforts.

### 1.4. Comparative Analysis

A comprehensive analysis comparing ultrasonic sound wave technology with traditional methods of wild boar deterrence unveils the distinctive advantages and ethical considerations that position ultrasonic technology as a promising solution. Traditional methods, often involving physical barriers, loud noises, or bright lights, have been prevalent in attempts to mitigate wild boar attacks. However, these approaches present challenges that the proposed ultrasonic technology aims to overcome.

Traditional methods, such as erecting fences or employing physical barriers, can have unintended consequences on local ecosystems. These structures disrupt natural ecological dynamics, potentially altering wildlife movement patterns and migration routes. In contrast, ultrasonic sound waves offer a more targeted approach. By specifically influencing the sensory perception of wild boars, ultrasonic technology minimises the ecological footprint, avoiding disturbances to non-target species and maintaining the delicate balance of local ecosystems. Chemical repellents have been a common choice for deterring wild boars; however, their application raises concerns about environmental contamination and unintentional harm to non-target species. The introduction of chemicals into ecosystems can have lasting effects on soil quality, water sources and vegetation. Ultrasonic sound waves, on the other hand, provide a chemical-free alternative that avoids these environmental pitfalls. The technology emits sound within the hearing range of wild boars, achieving deterrence without introducing harmful substances into the environment.

Traditional methods involving loud noises or bright lights pose challenges related to human disturbance. Local communities neighbouring agricultural fields may experience disruptions, leading to conflicts between farmers and residents. In contrast, ultrasonic sound technology operates at frequencies beyond the human auditory range, ensuring minimal disturbance to nearby populations. This discreet nature addresses a critical concern associated with traditional methods, fostering a more harmonious coexistence between agricultural practices and local residents.

One of the key advantages of ultrasonic technology lies in its targeted deterrence. Conventional methods often create a broad deterrent effect that may impact a wide range of wildlife beyond the intended target. This lack of specificity can lead to unintended consequences, affecting non-target species and potentially disrupting the natural balance of the ecosystem. Ultrasonic sound waves, precisely tuned to the hearing range of wild boars, offer a focused deterrence strategy. This specificity enhances the ethical viability of the solution, minimising collateral effects on other wildlife. The humane treatment of wildlife is a crucial aspect of any deterrence strategy. Traditional methods, such as trapping or harming animals, raise ethical concerns about the well-being of the targeted species. Ultrasonic sound technology stands out as a humane alternative, causing no physical harm to wild boars while effectively discouraging them from entering agricultural fields. This ethical dimension is vital for garnering public support and ensuring the responsible and compassionate management of wildlife conflicts.

The impact of wild boar deterrence extends beyond agricultural fields to the communities residing in affected regions. Traditional methods that involve loud noises or visual disturbances may lead to conflicts with local residents. In contrast, the discrete nature of ultrasonic sound waves, falling outside the human auditory range, minimises objections and conflicts with neighbouring communities. Effective communication campaigns further enhance public understanding of the technology's benefits, fostering goodwill and support for its implementation. Considering the long-term sustainability of wild boar deterrence methods is essential for effective wildlife management. Traditional methods may involve structures that degrade over time or require ongoing maintenance, leading to increased costs and potential disruptions. Ultrasonic sound technology, once installed, can operate continuously with minimal energy consumption. This sustained effort contributes to long-term sustainability by providing reliable and consistent protection against wild boar intrusions, reducing the need for frequent interventions and maintenance.

The adaptability of deterrence methods to diverse agricultural landscapes is a critical factor for their practicality and effectiveness. Traditional methods may lack flexibility, especially when faced with varying terrains, vegetation, or obstacles. Ultrasonic sound technology can be incorporated into various form factors, including stationary devices or mobile units, depending on the needs of the agricultural landscape. This adaptability enhances its usability across different scenarios, ensuring a versatile solution that can be tailored to the specific requirements of farmers and land managers.

In conclusion, the comparative analysis highlights the significant advantages of ultrasonic sound technology over traditional methods in mitigating wild boar attacks on agricultural fields. The ecological sensitivity, ethical considerations, minimal human disturbance, targeted deterrence and long-term sustainability contribute to positioning ultrasonic technology as a promising and innovative solution to the persistent challenge of wildlife conflicts. As agriculture and wildlife management evolve, the adoption of technologies like ultrasonic sound waves presents an opportunity to achieve effective deterrence while preserving the delicate balance between agricultural productivity and environmental conservation.

## 2. Methodology

The use of ultrasonic sound waves for wildlife deterrence is not a novel concept. Previous studies have explored the effectiveness of ultrasonic technology in deterring various species, including rodents and birds. Research indicates that animals, such as wild boars, with acute hearing within specific frequency ranges, can be influenced by ultrasonic sound waves. The proposed frequency of 35000 Hz aligns with the auditory perception of wild boars, making it a targeted and efficient method of deterrence. The ultrasonic producing device is not a novel concept, it is previously used for various purposes like bird repellent and even in other types of repellent but different concepts and strategies are used in those devices. An experiment showed that the activation of the deterrents using ultrasonic sound reduced the use of the treatment area by red deer by 48.96% (up to 66.64% when it was assessed on the internal lines and achieved a reduction of 67.71% in the number of deterrent-line crossings [14].

An optimal approach to address this challenge is by utilising ultrasonic sound waves with a frequency of approximately 35000 Hz. Wild boars possess an acute sense of hearing within the frequency range of up to 40000 Hz, which makes the 35000 Hz frequency well- suited for deterring them while avoiding interference with human activities. Humans, with a hearing range of up to 20000 Hz, will not perceive the ultrasonic sound, ensuring that the deterrence mechanism remains discreet and non-intrusive to people living in proximity to the affected areas. As the wild boars may get habitual to the sound we will be producing the sound at random intervals of time from 2 minutes to 15 minutes and the duration of the time would be irregular that may last from 10 seconds to 5 minutes. This irregular pattern will tackle the problem of becoming habitual. The Lights will be integrated with the machine which would turn on during the night time which would move its rays so that it would scare the wild boars.

This is the most basic model of the machine which would be more affordable. For greater accuracy the machine will be integrated with motion sensors at the boundary of the field so that it would activate the ultrasonic device after reading the motion of animals. As this will not be active all the time

the boars will not get habitual to it. The panic alarm will be included in this model which will make noise after detecting the movement near the field boundary so that the farmers nearby will algo get alert. This would reduce the danger of humans being attacked by the wild boars and even they can make boars run away from the fields.

### 2.1. Construction

The intricate construction of the ultrasonic sound wave technology system designed to deter wild boar attacks on agricultural fields involves a sophisticated integration of various components. At the heart of the system lies the ultrasonic sound wave generator, meticulously engineered to emit variable frequencies around 35,000 Hz [Design] which is finely attuned to the heightened auditory sensitivity of wild boars. Powering this technology is a combination of sustainable sources, with the option to integrate solar panels for harnessing renewable energy and robust battery systems ensuring uninterrupted functionality, even during periods of low sunlight or adverse weather conditions. For optimised device placement, an adaptive algorithm can be incorporated into the system, accounting for dynamic factors such as seasonal variations and shifts in wild boar behaviour. In advanced configurations, artificial intelligence (AI) algorithms may be seamlessly integrated. These AI algorithms bring an additional layer of sophistication by adaptively modulating ultrasonic frequencies based on real-time data, learning from ongoing interactions with wild boars to enhance deterrence efficacy https://www.researchgate.net/publication/318960311_Design_and_Development_of_Variable_Frequency_Ultrasonic_Pest_Repeller.

Encased in a durable and weather-resistant housing, the system features an adjustable emission mechanism that meticulously controls the timing and duration of ultrasonic sound waves. This intentional variability prevents wild boars from acclimating to a predictable pattern, thus maintaining the effectiveness of the deterrence strategy. As an optional enhancement, an integrated lighting system may be included, strategically designed to emit bright flashes during nighttime, providing a visual deterrent in conjunction with the ultrasonic auditory signals. The system incorporates monitoring sensors designed to detect wild boar activity and system malfunctions, providing valuable data for ongoing optimization and maintenance. In line with a community-centric approach, a user-friendly interface facilitates community engagement. This interface empowers local residents to actively participate in the oversight of the technology by reporting observations, receiving system updates contributing to the continuous improvement of the system.

To ensure adherence to local wildlife regulations and guidelines, a regulatory compliance mechanism is integrated into the system. This mechanism streamlines data tracking and reporting, essential for legal compliance, permit renewals consultations with relevant authorities. A documentation and communication module add a layer of transparency by maintaining detailed records of system performance, modifications and community engagement activities. The detailed construction of this ultrasonic sound wave technology system is a testament to the sophistication and innovation employed to address the challenge of wild boar attacks on agricultural fields. By seamlessly integrating advanced technologies, sustainable practices and community engagement, this system stands as a comprehensive and effective solution for mitigating conflicts between agricultural activities and wildlife.

### 2.2. Challenges and Limitations of Ultrasonic Sound Technology

While ultrasonic sound technology holds promise as an innovative solution, it is essential to acknowledge the challenges and limitations associated with its implementation. Adverse weather conditions, such as heavy rain or strong winds, might impact the functionality of ultrasonic devices. Proper device placement to cover target areas effectively poses challenges, considering variations in terrain, vegetation interference and the presence of obstacles. Battery life and maintenance requirements also require careful consideration to ensure continuous and reliable deterrence. The effectiveness of these deterrents may be lost after 6–7 weeks as there is a possibility that wild boars get familiar with the sound and become habitual. They may dare to enter the field and even after entering if they don't feel danger they may come again and again.

## 3. Conclusion

The integration of ultrasonic sound technology as a method for deterring wild boar attacks on agricultural fields offers a promising and innovative solution to a persistent challenge. Through an in-depth exploration of its benefits, challenges and implications, this technology has the potential to revolutionise the way we manage wild boar conflicts while maintaining the delicate balance between agricultural productivity and environmental conservation. The proposed recommendations focus on research advancements, monitoring and adaptation, public engagement and ethical considerations, contributing to the effectiveness, ethical viability and long-term success of ultrasonic technology for wild boar deterrence.

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