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Environmentally Friendly Control of Pests for Human Health

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Abstract
Concern about human health and sustainability of the environment has raised the awareness to employ environmentally-friendly pest management strategies. Traditional chemical-based approaches, although, effective may endanger the ecosystem, biodiversity and well being of the people. In this paper, author describes the sustainable methods of pests control and implies integration of biological, cultural, and technological novelties in order to minimize the use of the synthesized pesticides. Special focus is put on such practices as integrated pest management (IPM), application of biopesticides, modification of habitats and community-based strategies, etc. that increase long-term efficacy, and protect human health at the same time. The discussion outlines the twofold advantage of lowering process-related environmental pollution as well as enhancing general well-being through the promotion of cleaner food industries, living quarters, and protection against the diseases transmitting vectors. After all, it is sustainable pest management that can be defined as a decisive way of achieving a balance between the ecological integrity and human well-being.

Keywords: ***Sustainable pest management, eco-friendly pest control, integrated pest management (IPM), biopesticides, human wellness, environmental health, vector control, biodiversity, food safety, green technologies.***

1.Introduction
Because people consider pests as a severe inconvenience to their achievements, they have always presented a major problem to human society not only affecting health but also stability of agriculture, food output, and wider ecosystems. These animals like insects, rodents, ticks, mites, and exotic animals have the ability to cause, damage to an extent that is much more than being a nuisance. They threaten food security, wipe out crops, contribute to the propagation of infectious diseases and the loss of natural habitats, biodiversity, and put infrastructures and families at risk(1). Over the centuries the main remedy to pests resorted to was the chemical intervention especially the use of pesticides. Although they have concurrently achieved short term successes, these methods brought about collateral effects that included pollution of the environment, evolution of resistance by the pest organism and the health hazard to human and animals. With the world dealing more with sustainability and ecological resilience concerns, it has been apparent that there are voiced concerns to review the paradigm of the management of pest control to an integrated, sustainable and health-oriented approach.

Pest control development illustrates both the creativity and being able to meet new challenges. Earlier in the decades, integrated pest management (IPM) was developed which is a systematic science based strategy using biological, cultural and chemical means to curtail pest damage and yet minimize the use of pesticides. Nevertheless, conventional IPM practices have been proven to have flaws as global conditions have metamorphosed, causing changes in climatic conditions, and urbanization in part due to globalization of commodities and change in ecological equilibrium. To give an example, climatic change has shifted geographic location of multiple vectors so that the populations that were safe are now at the risk of acquiring a vector transmitted diseases like a dengue or Zika or malaria. Likewise, agricultural intensification and the expansion of international trade in goods have facilitated more efficient spread of invasive pests, putting biodiversity and food at risk. These truths reveal that although IPM gave good groundwork it is necessary to improve and expand these ideas into a more general system of principles that focuses not only on control but also on long-term sustainability, and preventive as well as providing a general well-being.

This awareness has led to establishment of Sustainable Pest Management (SPM) as a present day, proactive approach. In contrast to the traditional approaches that are focused on achieving only the direct shrinking of pests, SPM takes into consideration social, environmental, economical, and health aspects(2). It lays emphasis on cautious monitoring, risk analysis, early alert system, ecology conservation and wise application of technology. Positioning pest control as part of a sustainable paradigm, SPM aims to preserve natural resources, to defend the

health of people, and to support sustainable development. An example is SPM in food systems where more focus is given to approaches that guarantee sustaining the soil, conserving useful species, and minimizing the possibility of pesticide residue ending up on food chains. In the field of public health, it is consistent with preventive action against the diseases that are transmitted by vectors, to minimize not only morbidity but also mortality, and at the same time, enhance community resilience. Therefore, SPM is a global vision which cannot only conflict with international pledges like United Nations Sustainable Development Goals (SDGs), i.e., those relevant to health, hunger elimination, poverty alleviation, and sustainability of the environment.

China has played a significant role especially in the development of both theory and practice of sustainable control of pests. Being the largest, by the number of population, developing country and the major producer of various agricultural fertilisers, China has been struggling with indescribable challenges of pests, both in form of locust plagues and the irritating vectors(3). However, it has also been leading in innovation of pest surveillance, early warning systems and multisectoral pest control methods. There is a growing appreciation that pest management must not be isolated but must tie in with the larger environmental/health goals, and as such national policies have been leaning more and more toward the concept of sustainability not just in agriculture, but also in areas of public health promotion. An illustration is the use of China in the management of dengue fever which has facilitated models that use surveillance driven vector control, coupled with community engagement involving an increased proactive approach towards an incident, instead of a reactive one. This has also added worthy experiences to other countries that also have had the same challenge.

Notably, pests cannot be viewed as health or crop threats in isolation; their effects are cross linked across various spheres of human health. This relation is aptly highlighted by the fact that the Food and Agriculture Organization (FAO) estimates that as much as 40 percent of the world food crops are lost each year as a result of pests and plant diseases, which is a huge number. Similarly, according to the World Health Organization (WHO), nearly 80 percent of global population is still under the threat of one or more vector-borne ailments, and they are related to hundreds of thousands of deaths a year. These statistics point out that pest management cannot be categorised as marginal since it is the central decider of international health, sustainable development. The challenges of invasive species, resistant pests, and climate changes-driven modifications only enhance the need to use adaptive, innovative, and sustainable approaches.

Shifting to SPM is also a strategic change in the way we conceive: putting an end to short-term solutions of suppressing pests to a more systems-oriented thinking balancing ecological integrity and human requirements. It needs an interdisciplinary approach among the fields of public health, agriculture, forestry and environmental sciences and must involve the populations and policymakers. SPM, rather than operating only in response to emergencies when pest outbreaks occur, encourages preparedness, prevention, and resilience. It also requires an understanding of the economic facts of pest control where procedures not only satisfy the ecological concerns of procedures, but should be economically viable and socially acceptable too(4).

To conclude, the emergence of sustainable pest control is the necessary threshold in the world effort to resolve one of the oldest problems of humankind. SPM has placed the well-being and health as its central focus, which intends to balance the pest control with ecology, ecological guardianship, health and social development. In the next parts of this discussion, its negative effects will be discussed in a more detailed way, the emerging problems and research gaps in the existing strategies will be studied, the transition of the IPM to the SPM, as well as the future outlooks of the integration of sustainable strategies within the global health and environmental priorities. Globally, the vision through this perspective now clearly does not regard pest management as a technical endeavor culgated within a silo, but as a gift to sustainable development and the human advancement.

2. The Far-Reaching Consequences of Pests on Human Systems and Ecosystems

In various forms, pests pose some of the greatest challenges to human existence, the development of the society and the ecosystem. Although the term pest is loosily thrown around most of the time to imply organisms that are annoying or that are causing not a wanted hassle, the effects are much more dire when looking at the reality. Such living creatures, including mosquitoes, ticks, rodents up to invasive plant species, and insects that can destroy crops, can cause enormous harm in a variety of spheres. They impact aspects of health related to the population, farming, food security, the economy, biodiversity and even culture. In order to truly understand the importance of sustainable pest management, we should first begin by looking at the very wide range of the pernicious effects that pests have and the fact that these effects spread to other related systems that help maintain human wellness.

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The effect of pests on the public health is one of the aspects of greatest concern. Transmission of some of the deadliest infectious diseases in the world occur through disease vectors, which are mosquitoes, sand flies, ticks, fleas and snails. The World Health Organization described that almost eight out of ten people in the world are still vulnerable to acquiring at least one of the vector-borne diseases, such as malaria, dengue, chikungunya, yellow fever, Zika virus infection, Japanese encephalitis, and leishmaniasis(5). This group of diseases alone causes death of more than 700,000 individuals per year hence a very important issue to global health by means of vector-borne illnesses. Malaria alone contributes to more than 200 million cases annually and over 400,000 deaths which are mostly African children. On the same note, Dengue fever infects close to four billion people in more than 129 countries around the world causing the deaths of tens of thousands every year. In addition to death, the diseases impose a huge burden of suffering, financial loss, and healthcare burden. Outbreaks can destabilize society, inhibit productivity and lock communities into cycles of poverty. Therefore, pests as much as they are annoying, they are also human sources of grave torment.

TABLE 1 Key Consequences of Pests Across Human Systems and Ecosystems

Domain	Examples of Pests	Major Impacts
Public Health	Mosquitoes, ticks, sandflies, snails, fleas	Transmission of malaria, dengue, Zika, chikungunya, leishmaniasis; 700,000+ deaths annually
Agriculture & Food	Locusts, aphids, crop borers	30–40% of global food crops lost yearly; food insecurity; reduced farmer income
Animal Husbandry	Ticks, biting flies	Spread of babesiosis, theileriosis; reduced livestock productivity; multi-billion losses
Infrastructure	Termites, rodents	Structural damage to housing; fires from gnawed wiring; ~$1B annual loss in China
Environment	Fire ants, pinewood nematode, water hyacinth	Biodiversity loss; forest destruction; disruption of ecosystems and carbon balance
Economy	Cross-sectoral (all above)	Billions in healthcare costs, crop losses, livestock decline, and global trade impacts
Social Equity	All pest groups	Disproportionate burden on poor/rural communities; cycles of poverty and vulnerability

Pests have a debilitating effect on agriculture and foods in addition to health. Both plant pests and diseases are reported to destroy up to 40 per cent of food crops grown in the world (Food and Agriculture Organization). Such loss translates to millions of tons of food which would instead feed the communities yet it is allowed to lead to hunger and malnutrition. To the rural populations of developing countries, crop loss finds its consequence not only in the short-term cuts in food supplies but also in the undermining of livelihoods, lower household income, and continued susceptibility to poverty. Swarms of locust, to use an example, can destroy whole bills in a few days as it would be experienced in East Africa and South Asia in recent years. Another pest is known as Aphids, which destroys hundreds of plant species through sap feeding and the spread of plant viruses causing massive losses to agriculture. Pest damage of grain aloneis estimated at approximately 40 million tons in China alone which has the potential to feed close to 80 million people. These numbers indicate the enormous contribution that pests make to disorganizing food security both locally and globally.

Pests also cause a great danger to livestock industries and animal husbandry that are very essential sources of protein and economic revenue to the entire world. Examples are ticks and biting flies, which decrease the productivity of cattle by causing stress, causing diseases like babesiosis and theileriosis and generally decreasing health. In Tanzania, losses through tick-borne diseases were estimated to be about 55 million USD annually in livestock sector. The cost of such vector-borne diseases in animals to the economy worldwide is in billions of dollars because the diseases not only decrease in both meat and milk production, it also hinders trade and

reproduction of animals. This convergence of pest management with animal health also provides one more reason why integrated, sustainable strategies are necessary: to safeguard, not only crops but also animals that supply the human population.

In addition to having negative effects on agriculture and livestock, pests weaken the built environment and infrastructure. An example is termites which are commonly referred to as silent destroyers due to their capacity of eating wood and other edifices, unnoticed. Termites cause billions of dollars worth of damage yearly weakening their buildings, houses, furniture, and storage facilities as they have more than 3,000 known species. Economic losses among houses caused by termites in China alone are estimated to be approximately a one billion USD per annum (6). The same applies to rodents, who besides spreading the disease issue, also present fire hazards due to chewing on electrical wires and damaging facilities where they are stored, and polluting foodstuff reserves. These aspects of pest damage that are frequently ignored show that their effects are far beyond their connection with health and agriculture and go all the way to urban planning, house security, and disaster protection.

Pest environmental impacts are also very relevant. Invasive species pose an ecological threat like the red imported fire ant (Solenopsis invicta), pinewood nematode (Bursaphelenchus xylophilus), or water hyacinth (Eichhornia crassipes): they destabilize the biodiversity of local ecosystems, disturbing populations of both plants and animals. Invasive pests are extremely hard to get rid of once they are introduced and may cause long-lasting irreversible landscape changes. As an example, the pinewood nematode ruined vast sections of pine woods in Asia bringing economic losses to the tune of millions, and causing ecological balances to go haywire. An average of tens of millions of hectares of forests are adversely affected every year by forest pests and plant diseases, which contributes to the failure of initiatives to conserve forests and sequestration of carbon and mitigate climate change. The pests in such a manner are not only a problem of agriculture or even a medical issue but also a direct hindrance to the sustainability of the environment and biodiversity.

Economic loss on national and global levels is also another frequently underestimated aspect of the pest impact. The effects of the destruction of crops, diseases, and destruction of infrastructure by pests reverberate through to the whole economies. The impact of lower agricultural productivity will be an increase in food prices, a decrease in export earnings, and a debilitated rural economy. The burden of diseases brought about by vectors creates adverse consequences on the productivity of labor, the high costs of healthcare and the overall impediments in development. In livestock, lower output reduces household revenue in livestock and in urban locations, rodent, cockroach and termite infestation increase household expenses as well as government expenses. All these combine to give an estimated economic loss to the world of pests running into hundreds of billions on yearly basis due to which there is an urgent need to have systematic control.

3.Emerging Barriers and Deficiencies in Modern Pest Management

The practice of sustainable pest management has progressed significantly over the past decades, but the international community still has to deal with huge obstacles that compromise their efficiency. The challenges are the complex dynamic interrelationship between the aspects of environmental change, globalization, technology gaps and social behavior. These emerging stumbling blocks need to be identified and the accompanying deficiencies eliminated systematically to come up with resilient systems. The subsequent subimitations raise the most burning problems which obstruct a successful pest destruction and prevention in the 21st century.

1. Changing Vector Ecology and Climate Change

Climate change is one of the most influential factors that can influence pest dynamics in the world. The increase in global temperatures as well as modifications in precipitation, and modifications in ecological patterns have increased the geographical coverage of most vectors. As an example, Aedes aegypti and aedes albopictus are the main vectors of dengue, Zika and chikungunya and are expanding to new areas where they last were unable to survive. This growth reintroduces vector borne diseases to millions of new populations. As an example, over 0.9 billion individuals in China are already living in dengue risk areas and risk areas are estimated to expand with rise in temperatures. Likewise the Culex pipiens mosquitoes of the complex developed populations at new altitudes, now becoming able to spread in the Tibet city of Lhasa. These ecological changes make surveillance and control more complicated because the authorities in health have to adjust continuously to unpredictable changes in the distribution of the vectors.

2. Globalization and Pests Rapid Spread

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In our globalized world, which has witnessed more travel, trade and urbanization, the world has experienced faster spread of pests. International aviation is able to carry vectors of diseases across continents in a few hours and international shipping gives invasive agricultural pests the capability of hitch-hiking across oceans. An example of this is in Europe, which has undergone unprecedented shifts in the status of vector-borne diseases in the early 21 st century in part due to international travel and trade. Also in agriculture, the fall armyworm and the red imported fire ant are invasive species that have quickly spread across Asia and Africa incurring massive losses on agriculture. The pests globalization poses special problems, and local outbreaks may rapidly scale to regional or global outbreaks well beyond the control capacity of a nation.

3. Insect Resistance and Chemical Dependency

Overuse at both the agricultural and the household level of chemical insecticides and pesticides has resulted in a severe issue of resistance in the many pest populations. Agricultural insects as well as mosquitoes and even rodents are resistant to common chemicals in use and only traditional methods are ineffective. The importation of household insecticides only in 2019 is more than 2.1 billion USD in China and has been growing steadily year by year. Nevertheless, excessive use of those chemicals is also involved in resistance in addition to environmental pollution and harmful consequences on human health. Resistance leads to a vicious cycle: as pests are more difficult to control farmers and households tend to apply chemicals in greater amounts which only speeds up the problem. This can only be solved by using comprehensive strategies and innovation of non-chemical methods.

4. Technological and Ability Shortages

Yet even with these developments, infrastructure and technological gaps exist in pest management in many countries, especially developing countries. Among the limitations are weak surveillance systems, poor rapid pest identification capacity and weak advanced diagnostic and monitoring technologies. Some lack even the most rudimentary laboratory capability to identify the outbreak early enough and instigate a response. Also, the modern technologies of geographic information systems (GIS), remote sensing, and molecular diagnostics are unevenly integrated into the process of work with pests. In their absence, there is a limit to trying to forecast outbreaks or tracking the spread of the pest to the populations, at risk of being caught in another attack by infestations or epidemics.

5. Human Behaviour and Social Consciousness

A key, yet underestimated aspect of pest management is human behavior. Such may include poor waste management, stagnant water accumulation, inadequate sanitation creating a conducive environment of breeding of vectors like mosquitoes, and rodents. Where there is inappropriate use of insecticides at the urban area, the problem of resistance can become worse and the insecticides are likely to leave toxic residues within the houses. Ignorance on how to protect oneself against these diseases, by utilizing means like applying mosquito nets, repellents or altering the environment, further undermines the position of any community to fight against vector-borne pathogens. Education and outreach toward the general population is mature in most areas and poses a challenge to the long-term sustainability of community action against pests.

6. Transforming Urbanization and Habitat

Urbanization is affecting the ecology of pests through the establishment of dense artificial environments which offer plenty of resources to the pests. Crowded residential housing, ineffective drainage facilities and unfavorable infrastructures in fast urban developing areas give rise to rodent infestations, the breeding of the cockroaches and the mosquitoes. In addition, the process of turning the natural environment into an agricultural or urban landscape pressures pests to adapt to new environments, where they may develop well under human dominated conditions. Not only does the trend further complicate pest control, but it also brings about the issue of the interfacing of urban development with resiltience in the areas of public health.

7. Policy and Multisectoral Coordination gaps

Pest management is cross-sectoral in nature and concerns itself with the obligation of the public health, agriculture, forestry, trade and environmental protection. Many countries however lack the effective mechanisms that oversee the coordination of action in these sectors. There exist inefficiencies and gaps where policies are largely fragmented in a manner that agricultural pest management is separated and dealt with differently to that of the control of the vectors. A prime example is that measures against pests on farmlands might not be aligned with the public health goals, although both programs use common surveillance and intervention mechanisms. Moreover, institutional priorities, and funding are short-term, and based on crisis response instead of long-term prevention.

These policy gaps need to be bridged through harmonized models of governance that aims at harmonizing the pest control with greater aspects of sustainability.

4. Development of Pest Control Techniques

The pest management process has had a phenomenal evolution in the last one hundred years. This heavy use of pesticides, mostly chemical, has over time that evolved to more inclusive and sustainable practices(7). Such a revision is due not only to the unreasonableness of previous approaches but also to the need to ensure that the protection of pests should be consistent with the environment, community safety, and resiliency. The history of the evolution of Integrated Pest Management (IPM) to Sustainable Pest Management (SPM) exemplifies this development, the shift toward proactive approaches that can be holistic systems where man and nature are actively and satisfactorily planned together to protect both well-being and the environment.

1. Emergence of Integrated Pest Management (IPM)

IPM appeared in the middle of the 20 th century to address the global overuse of artificial pesticides. Farmers and health authorities had realized that the use of chemicals alone could not be sustained since there was resistance, ecological destructions, and health hazards. The problems raised by IPM were to be avoided by integrating biological, cultural, mechanical and chemical techniques through a scientifically based system. The basic ideology of IPM was not eradication but prevention and minimization with an aim to maintain a population of the pests at the sustenance level.

In farming, IPM has presented methods, including crop rotation, predator introduction, resistant plants and selective, reasonable use of pesticides. Integrated Vector Management (IVM)A subset of IPM that focused on specific control of mosquito, tick, and other vectors through environmental management and surveillance applied in public health. Although the step of IPM could be called an important association, it also displayed the areas of weakness: application needed much technical knowledge; planning was uneven; and it still leaned on the use of chemical measures when other options failed.

2. Restrictions of IPM in A Changing World

Although scientifically-based, IPM struggled to keep up with the fast moving environmental circumstances in the world. New pests, modified disease vectors, and enlarged zones of threats by climate change, globalization, and urbanization complicated the current IPM choices more than traditional tactics could supply. Any example like the re-emergence of dengue and the distribution of invasive species such as the fall armyworm has shown that we need not only technical plans, but also social, economic and ecological plans.

The other limitation was that IPM practice tended to be fragmented. Agricultural IPM programs came to be independently of the public health programs hence being inefficient. Moreover, IPM was knowledge- and work-intensive, which necessitated a heavy surveillance and community involvement that could not always be implemented in resource-poor environments. These drawbacks then, on a longer-term scale, became apparent, and there was a need to have pest control conditions within a broader, more flexible system, one where sustainability was implanted into the system.

3. Origin of the Sustainable Pest Management (SPM)

The idea of Sustainable Pest Management (SPM) appeared in the beginning of the 21 st century as an extension and improvement of IPM principles. As compared to previous strategies, SPM has a direct connection in pest management to all the long-term objectives including environmental sustainability, economic sustainability and the general well-being of humans. It understands that pest control is not to be achieved in a vacuum but should be embedded in systems to safeguard natural resources, ensure food security and diminish inequality in health outcomes.

A major strength of SPM is its focus on surveillance-based management whereby pests are not only observed, but risks are assessed and measures to control the situation are planned/acted pro-actively and not necessarily on a reactive basis. It advocates environmentally sound activities, such as, use of biological control measures and handling of habitats up to more sensible use of pesticides when there is extreme need. Notably, SPM combines the participation of the general population and cross sectoral co-working, such that farmers, health workers, policymakers and communities are involved in designing and maintaining intervention (8).

4. SPM Components Core

So SPM may be approached with a few major elements:

- Surveillance and risk assessment: Pest population, disease vectors and environment, is monitored continuously to give early indication to be used to make timely interventions.
- Integrated Control Planning: Risk thresholds, ecological impact, and cost-effectiveness are used in making such decisions and guarantee effective and sustainable interventions.
- Green Technologies: The use of biological control, ecological engineering and safe pesticides in order to limit dependence on chemicals and maintain biodiversity.
- Monitoring and Evaluation: The effectiveness of the interventions is monitored on top of managing resistance and ensuring sustainability in the long term, which enables strategies to adjust to variations in circumstances.
- Community involvement/Cooperation: The community is very involved, because only through the combined effort of the community can positive sustainable results be achieved.
- These pillars will explain how SPM goes well beyond IPM by incorporating pest management into the larger contexts of ecosystems and social ecologies.

FIGURE 1 SPM Improves Pest Management Outcomes

5. Case Study Germany: Dengue in China

The control of dengue in China has given an example that can be used as a SPM application. Authorities did not pursue only chemical extermination of Aedes mosquitoes but took up a surveillance approach. The activity initiated with the use of constant monitoring of the density of mosquitos and the disease transmission trend, with control planning and systematic risk assessments being the next steps. The interventions focused on environmental control and management, breeding site elimination and community participation in the control of the vectors.

This strategy of keeping Aedes density at a level characterised by no welfare effect (measured by indices like the Breteau Index) whereby such a density level prompts proactive risks elimination and preventive over responsive outbreak control reactions(9). This change was not only bettering the control of the disease but it also strengthened the involvement of the people and intersectoral cooperation. This has been served as an exemplar in the regional and world strategies because the model of China has since demonstrated the practical benefits of SPM in contrast to traditional approaches.

6. Worldwide Awareness and Policy Accommodation

The shift in thinking towards SPM has already been strengthened by global institutions like the World Health Organization (WHO). The Global Vector Control Response 20172030 and the previous framework developed by WHO identified sustainable methods as the key interventions that will help to mitigate the due burden of vector borne diseases. In the same manner, the same idea has been propagated through agricultural agencies on a wider scope of food security or even biodiversity conservation. Positioning pest management into sustainability agendas has led SPM to be seen as a required approach to the attainment of the Sustainable Development Goals (SDGs) such as health (SDG 3), eradication of hunger (SDG 2) and protection of the environment (SDG 15).

7. SPM Economic and Social Benefits

Advantages of SPM are not limited to pest lowering. It has a direct connection with poverty alleviation because it has lower crop losses, and increased food security. In health, it reduces wastage in form of sickness and deaths which promote economic development. In addition, SPM decreases the exposure of the environment to pesticides protecting biodiversity and leaving future generations with healthy and robust ecosystems. And most importantly,

perhaps, SPM is equity conscious because it enhances access to tools and strategies to manage the heavy burden placed by pests on vulnerable people in such a way that it is accessible and sustainable.

5.Conclusion

Safeguarding the health of the public and lessening the burden of disease

Among the most straightforward contributions of SPM is its service in safeguarding the society against diseases transmitted by vectors. SPM focuses on shifting the spotlight of surveillance, risk compensation and preventive measures to that of outbreak prevention. The efficiency of this method is that it saves lives causing the minimization of the spread of malaria, dengue, Zika, chikungunya and other dangerous insect-borne diseases. In addition to reducing mortality, it decreases suffering, lowers the economic burden of patients costs and productivity losses. The advantages of these in weak areas are increased life expectancy and community resilience with regards to the rising health risks.

Food Security and Nutrition Strengthening

Pest management is also a major factor in sustainable pest management contributing to keeping the agricultural processes safe and leading to the food security of the world. Trimming down the crop loss, which usually ranges more than 30 40 percent annually, SPM helps produce more food and stabilize the food supplies. Notably, its focus on ecological farming like biological control and crop diversification means that production of food is attained without damage to the environmental wholeness. This multi advantage contributes to the struggle on hunger and satisfies people with safer and pesticide free food, enhancing the nutrition and diminishing the chemical contamination dangers.

Promoting Economic Growth and poverty Alleviation

The SPM implications to the economy are immense. The total damage that is caused by crop losses, diseases of livestock and the diseases that are caused by vectors costs billions and billions of dollars in a year which even then drift away the resources which could otherwise be used to build development. By alleviating these losses, SPM allows the farmers to save their lives, families to spend less on health care and governments to draw resources more efficiently. In addition, SPM increases the efficiency and improves rural development, as it reduces the dangers of pests and diseases. In developing countries it is especially important since pest-related losses tend to fuel poverty loops. By inclusive practices, SPM can assist in decreasing inequality and in more equitable economic development.

Fostering Sustainable Environment and Biodiversity

Through ecological stewardship, SPM is built as opposed to the chemical intensive approaches of yesterday. This gives consideration to conservation of advantageous species, maintenance of the natural habitat and reducing chemical introduction so that biodiversity is not swept away. In turn, healthy ecosystems are the sole suppliers of important services which include pollination, water purification, and climate regulation. With the connection of pest management to environmental conservation, SPM helps meet the international environmental protection goals and contributes to increased resistance to the rapid changes of global warming.

Stimulating Social Attributes Community Activity and Participation

The demand by SPM to engage communities in pest management activities is another of its characteristic features. Contrary to what happens in top-down interventions, sustainable strategies understand that the involvement of the people is the key towards achieving long-term success. The idea is that when families in general implement safe behaviour, when agriculture incorporated ecological solutions, and when an urban population diminishes sources of breeding vectors, controlling the pests will be a collective responsibility. This entitlement further achieves better results, as well as social bonding in the community. Further, the community participating ensures that solutions are culturally appropriate, fair and affordable to the targeted marginalized groups.

Collaboration Local to the Globe

None of the borders matters to pests and the diseases that are transmitted by vectors, as international cooperation is necessary. SPM promotes the collaboration between countries and regions, promoting the exchange of knowledge, technologies, and surveillance systems. International cooperation, led by entities, like the World Health Organization and the Food and Agriculture Organization, offers guidelines to take common action against threats of pests. Enhancing such networks means the local achievements can be regionalized and globalized by diminishing risks to everyone. Such cooperation will be even more crucial as globalization and climatic change bring about an increasing number of global challenges dealing with pests.

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Conflicts of interest

The authors have no conflicts of interest to declare

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