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Health and Environmental Hazards Associated with Agricultural Pesticides in Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The use of chemical pesticide in Ethiopian agriculture has a steady historically growth and strongly associated with the need to boost crop production and expansion in a high-input floriculture industry. An increased crop production and productivity is mainly dependent on effective and efficient pest management strategies. Recently, achieving these strategic goals of the sector seems to be impossible without intensive use of synthetic pesticides. Unfortunately, the chemical-based option of pest management was not able to deliver only the positively intended purpose of managing pests. It has raised a potential menace not only to public health and the environment but also to the fast-growing economy of the country. The main objective of this review was to highlight the negative health and environmental impacts of agricultural pesticides in Ethiopia. Literature based comprehensive review was made with the intention to influence stake holders in the sector to recognize the negative impact of agricultural pesticides to help them to devise a mitigating strategy and finally the authors tried to indicate solutions on this regard. Health conditions such as dizziness, nausea, skin and eye irritations, headache, vomiting and general discomfort after spraying are some of the self-reported direct health problems. Other chronic non-reported health problems/deaths were also associated with misuse (handling and disposal) of pesticides. Mismanagement of pesticides kills important organisms and are damaging to the biodiversity. Moreover, an intensive, non-responsible use of pesticides has increased the cost of pest management, accelerated the development of new pests and/or resistant strains (races) of pests and negatively affected the international trade of farm produces. Lack of awareness (poor pesticide management, disposal; and limited use of complete PPEs), obsolete pesticide stocks, prolonged

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storage, poor storage facilities, the lack of trained staff and national legislation for pesticide registration and monitoring system in the country are the main reasons associated with pesticide risks. Harmonized agriculture development policy, capacity building, organic farming, IPM compatible pesticides and gender-sensitive education will change the risk of agricultural pesticides.

Keywords: Agriculture; environment; health; pesticide.

1. INTRODUCTION

Land, improved inputs (seeds, fertilizers, pesticides and irrigation), labor, livestock and knowledge of improved inputs use are the major factors of agricultural production. Agricultural pesticides among others are a biologically active chemicals designed to kill target organisms for instance insects, disease organisms, disease vectors and rodents in agriculture and public health [1]. They are important determinants of sustainable development, sound environmental health and quality of life. It helps farmers to boost productivity significantly, a goal critical to structural transformation and poverty reduction, particularly, in regions like Sub-Saharan Africa (SSA), a conducive slot for many plants and animal disease-causing organisms. They are necessary component of modern agriculture; where, ~ 50% estimated crop yield, in warm climates, typical of developing countries would have been lost without its use [1].

However, its inappropriate (misuse or abuse) incur risks negatively affecting human and animal health or the surrounding environment, thereby decreasing net growth in productivity and well-being in the short and/or longer run [2]. According to Amera Sahilu [3], some pesticides like, Endosulfan and its related isomers used widely in Ethiopia are not registered (are prohibited) for use in most American, Asian and European countries. The health and environmental hazards of agricultural pesticides emanates from, not, only inappropriate and misuse of the chemicals but, also from inadequate disposal of obsolete pesticides and effects of obsolete pesticide stocks [4]. Therefore, the main objective of this review was to insight the health and environmental risks associated with agro-chemicals based on literature and to indicate future directions.

2. IMPORTANCE OF AGRICULTURAL PESTICIDES IN ETHIOPIAN AGRICULTURE

The Ethiopian development vision; “Building an economy which has a modern and productive agricultural sector with enhanced technology and an industrial sector that plays a leading role in the economy of sustaining economic development and securing social justice and increasing per capita income of the citizens” underlies to the Growth and Transformation Plan (GTP) of the economic and social development. Agricultural inputs such as, synthetic fertilizers, agricultural pesticides, improved crop varieties and cropping technologies and intensification of irrigation facilities among others are being increasingly used to boost agricultural productivity and production. The introduction of synthetic inorganic pesticides since 1960s [5] has allowed the dominance of their use in solving agricultural pest problems. This has continued to date and pesticides are widely used worldwide [6]. In agriculture, the safe and effective use of pesticides has successfully helped and is helping to solve various problems. These includes, scarcity of agricultural land, producing savings in labor and energy, hunger, pre- and post-harvest losses due to insects, weeds, fungi, bacteria and vectors of animal disease [7]. The rapid increase in the value of herbicides imported into Ethiopia and its adoption by smallholders in the last two decades has resulted significant positive labor productivity effect [8]. It can replace the ever-increasing demand of labor in a rapidly transforming economy of many countries including Ethiopia. On the other hand, agricultural pesticides help to increase agricultural productivity, thereby the crisis associated with the scarcity of agricultural land due to an ever-increasing human population growth in the country are reduced [8].

In Ethiopia, the shift from traditional to modern agriculture (use of genetically more uniform crop varieties and extensive practices) has resulted the development of new disease outbreaks and changes in disease trends towards epidemics posing huge economic losses in yield and quality [9]. This situation raised a need for alternative pest management option. As a result, chemical pesticides have helped the sector in this regard. Although it is difficult to single out the quantitative yield increment associated with pesticide use, due to lack of such studies, the introduction of

crop technology packages including agro-chemicals to boost agricultural production could make a huge difference in productivity [10]. For instance, cereal producing farmers' who followed a technology based supply driven intensification strategy consisting of enhanced supply and promotion of improved seed and fertilizers, on farm demonstration of improved farm practice and technologies, improved credit service for input purchase, in ten years period increased cereal yields from 1.12 to 2.33 tons per hectare a little over twofold [10]. This indicates that agricultural pesticides have played a crucial role in the agricultural transformation process and modernizing farming systems.

3. THE NEGATIVE IMPACT OF AGRICULTURAL PESTICIDES

The pesticide delivery system in Ethiopia comprises policy makers, researchers, pesticide manufacturers, wholesalers, retailers, civil societies and farmers of divergent interests, working in a dispersed manner with no concerted effort [3] to alleviate the pesticide associated harms. Misperception of uncontrolled generic pesticides use as a mere option to mitigate crop losses to pests enforced farmers to relied only on chemical options. Hence, the use of resistant varieties and pesticides is constrained by recurrent emergence of new pathogenic races (biotypes) and pesticide tolerance (resistance) which intern increases the demand for new products and increased rate and frequency of pesticide application. These coupled with the ill-implementation (ineffective and non-sustainable way at national and local level) of legal framework on pesticide registration, distribution and use in the country, caused an immense adverse health and environmental effects [11,6,12]. Moreover, huge amounts of pesticides are imported, some of these expire in storage before use, and their disposal became a major problem [12]. These factors have raised a question of environmental and human health hazards of synthetic pesticides.

Many of the current practices applied by smallholders relied on the input of broad-spectrum chemicals for pest management. The farmers feel spraying with chemicals is not only effective; but also, the only viable option available to them [13]. Overuse, misuse, and mismanagement of chemicals are common. Accordingly, environmental damage, reduction in agricultural productivity, health risks for users and food safety risks are potential dangers. The potential risks of these products are more intense and potent in areas where production of vegetable crops and floriculture industries are well established, like, the central rift valley of Ethiopia [14,15].

3.1 Impact on Human & Animal Health (Food Safety)

Protection of crop losses due to pest is as important as producing food and fiber, and agricultural pesticides have played a pivotal worth in minimizing such losses. However, the pertinent nature of these pesticides is not without negative (adverse) effects on human and animal's health. About 2.4 billion kilograms of pesticides are used worldwide annually, with 250,000 to 370,000 human deaths, most of which occurred in developing countries [16]. In Ethiopia using pesticides in agriculture is increased, 2400 metric tons [17] to 4125 metric tons of active ingredients [18]. Similarly, cultivated area under pesticides farming is increasing from 1.7 million hectares in 2007 to 2.4 million hectares in 2016 [19].

Fig. 1. Inappropriate pesticide spray practice by vegetable crop growers in Ethiopia (researcher own photo taken during on farm farmers pest management)

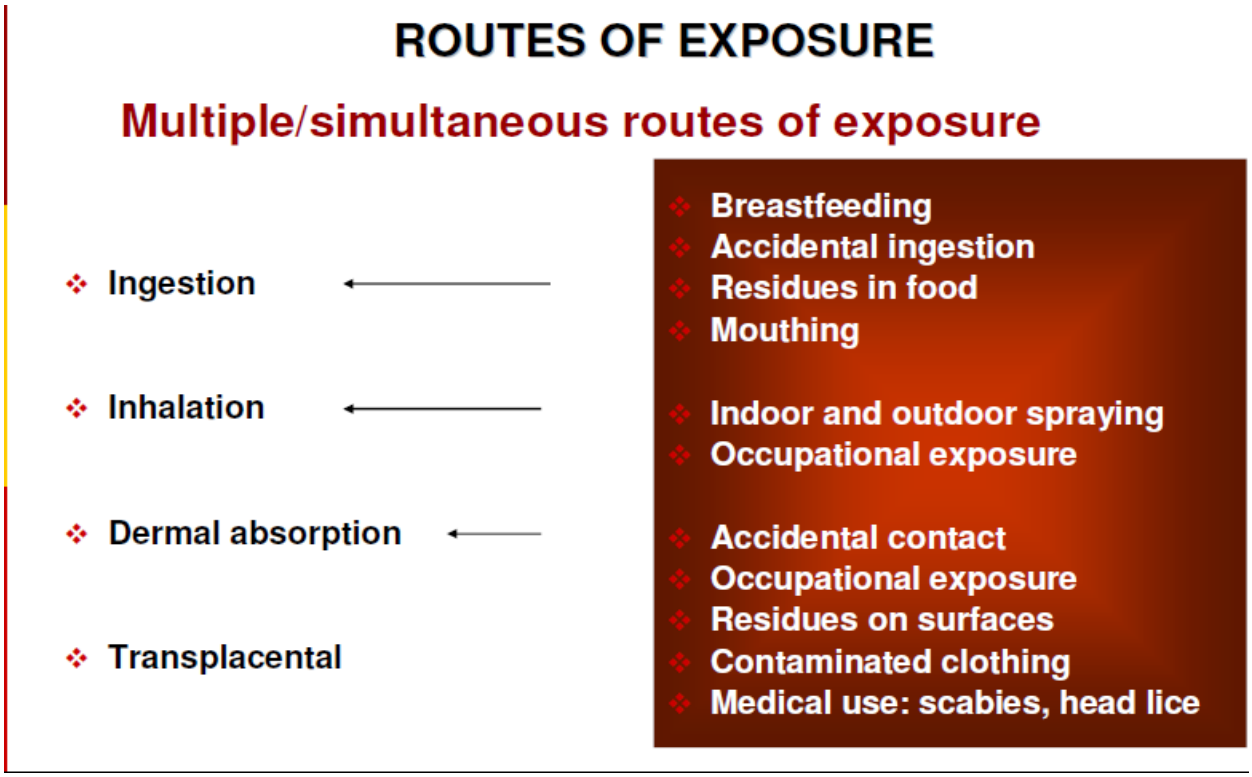

Fig. 2. Routes of exposure (*www.who.int/ceh*)

As a result, pesticide risks during handling, transportation, storage and use; pesticide residues in food commodities and their entry into the food chain has become a major cause of concern in Ethiopia [20]. Samples of various food commodities and environmental samples like soil and water collected from various parts of Ethiopia contained pesticide residues above maximum residue limit as prescribed under food safety standard authority of India (FSSAI), ministry of health and family welfare [20]. Besides, the residual effect, weak pesticide management like pesticide storage, misuse and abuse caused both acute and chronic toxicity on human and animals [12].

Health conditions such as dizziness, skin and nausea irritations, abdominal pain after spraying is some of self-reported impacts of pesticides [21,22,23]. In the central rift valley area, 94.3% of the farmers [24] used pesticides as part of their input in their agricultural activities [14]. Off which, about 31% of the practitioners claimed to feel unwell after pesticide spraying and 14.2% had a pesticide poisoning incident in their family. Assessment of pesticide health and environmental hazard on six districts of Amhara region [24] indicated different types of health problems on pesticide practitioners. Discomfort during pesticide applications (85.94%); headache (28.13%); nausea (6.77%); vomiting (13.02%); skin irritation (32.99%); eye irritation (26.91%) and general discomforts (2.26%) after pesticide application. There is also high prevalence of self-reported respiratory, dermal and neurological symptoms and acute pesticide intoxications among the workers on the flower farms of Ethiopia [25]. Congenital malformation and prenatal death during pregnancy following exposure to pesticides exposure (Gesesew Hailay *et al*., 2016) is the outcome of pesticides.

The use of banned Organochlorine pesticides (OCPs) like Dichlorodiphenyltrichloroethane (DDT) by small scale farm holders in the central rift valley of Ethiopia, the potential of pesticide health risks is increasing. Peoples who regularly consume fish above estimated mean daily intake, obtained from pesticide contaminated with pesticide are reported to be exposed to DDT health problem (Habtamu Wodajo, 2020). Seyfe Asrade et al. (2021) also indicated potentially high chronic health risk on chat chewer peoples due to the detection of higher pesticide residue level of pesticides (Profenofos, dimethoate, and chlorpyrifos) on Khat Leaves. Poor drinking water quality, higher pH, potassium and iron, 50 % above the maximum permissible limit of the

Ethiopian [26] is also reported. Accordingly, the fungicide spiroxamine poses a high chronic risk when the water is used for drinking [26]. Although it is not above the international MRL values, 2,4-D, aldrin, Endosulfan and DDT) were also detected in pre harvest and stored wheat grain samples in Hadiya zone, south nation, nationalities and peoples region of Ethiopia [27]. The presence of organochlorine pesticides (aldrin, endosulfan and endrin) in poultry feeds above MRL that could bioaccumulate and eventually lead to the contamination of table eggs and table meats as a result of these endocrine disruptors [28]. Pesticides residues of DDT, endosulfan, cypermethrin, and permethrin in red pepper and green coffee bean [29] and endosulfan sulfate, dimethoate, DDE and aldrin on rice, sorghum, commo millet [30], respectively, above MPL, indicates how much pesticide related health risk are catastrophic as roughly all most all Ethiopians food culture is dependent on these two commodities (pepper and coffee) and cereals and the potential daily intake of these toxins will probably be too much. Recently, Kumlachew Mulu et al. (2020) detected profenofos (from tomato, onion, surface water, floriculture effluent, and tap drinking water); metalaxyl (from onion and tomato); α- and β-endosulfan (from tomato); λ-cyhalothrin (from onion) above the European maximum residue limits (MRLs). This probably entails the health risks of pesticides viz food chain.

The negative impacts of pesticides are not limited on the health of humans but on animals too. Research study in Bale, south eastern Ethiopia (Bekele Tesfaye et al. 2021) reported mass dead, absconded, and dwindled damages on honeybees. The overall negative impacts of pesticides on honey bee and associated adverse effect on beekeeping in Ethiopia agriculture is well reviewed by [31]. A high acute risk of the fungicide spiroxamine and insecticides deltamethrin & endosulfan to aquatic organisms is indicated in research conducted by Berhan Mellese et al. [26]. The presence of organochlorine pesticides (aldrin, endosulfan and endrin) in poultry feeds above MRL that could bioaccumulate and eventually lead to the contamination of table eggs and table meats as a result of these endocrine disruptors.

3.2 Impact on the Environment

In Ethiopia, increased agricultural production and productivity are mainly relied on area extension, agricultural intensification and diversification. The latter two are an agricultural production increment strategies based at increased use of agricultural inputs like chemical fertilizers, pesticides and improved crop varieties. These strategies are not without posing environmental risks if not well managed and this is what is happening in the country. Water and soil pollution, especially by agrochemicals, are becoming important in some areas of Ethiopia [32].

The ecological adverse effects of pesticides at all levels of biological organization, loss in production, changes in growth, development and/or behavior, altered diversity or community structure, changes in system processes such as nutrient cycling, and losses of valuable species is reviewed by [33]. Different lakes in Ethiopia, for instance lake Ziway Akaki river and Aba Samuel reservoir are currently being polluted with pesticides such as DDT, DDE, DDD heptachlore epoxide and dieldrin (Habtamu Wodajo, 2020); [34]. Pesticides such as atrazine, chlorothalonil, dimethoate and endosulfan found to have possible and high risks on aquatic organisms, algae, Daphnia and fish [26].The floriculture industry uses too many pesticides and chemical fertilizers, which cause adverse effect on the environment. The excessive pesticides that are getting into water bodies are damaging the biodiversity and chemicals are killing useful organisms in the soil. Ninety nine percent (99%) of pesticides used are pollutant of the environment (soil, air, and water, or on nearby vegetation) and only ~ 0.1 % of the applied pesticide reaches to the target pest [35,15,36]. Use hazardous pesticides caused water and soil pollution [37,38]. The frequent use of pesticides has accelerated the development of new pests and/or resistant strains (races) of pests [9], Martin, 2008; [39]. Nearly, 1,000 major agricultural pests developed resistance to most commercially available pesticides [40]. This “pesticide slog” has led farmers to use stronger concentrations and/or more frequent pesticide applications, rising the risk of negative impacts on the environment.

4. DERIVING FACTORS TO HEALTH AND ENVIRONMENTAL HAZARD OF AGRICULTURAL PESTICIDES

For agricultural pesticides to have an impact on human, animals and the environment health there are a deriving (pushing) factors. Among which inadequate awareness of pesticide practitioners, poor legal institutions on pesticide

control, gender, lack and low adaptation IPM technologies and increased intensity of new emerging and re-emerging pest species and races (strains) contributed a lot.

4.1 Poor Legal Framework on Pesticide – poor Policy and Gap in Implementation

In Ethiopia, three-pesticide legislations (Plant Quarantine Decree No. 56 of 1971, Pesticides Registration and Control Council of State Special Decree No. 20/1990 and Pesticide regulation and control proclamation No. 674/2010) have been formulated in the last 40 years. However, these legislations are not without their limitations. Lack of detail pesticide registration and management procedure of imported pesticides, lack of interferences in the import, sale, and manufacture of unregistered pesticides [41] are some of the factors that increase health and environmental pesticide risks. Lack of facilities and infrastructures for analysis of pesticide formulations and residues, and the physicochemical properties of new and unregistered pesticides [41] are also another policy issues. Moreover, a huge gap between the policy and its implementation [41,6,1] is a principal reason for aforementioned human and environmental risks of pesticide. Key policy actors of Ethiopia have poor information available, motivation to implement policies and lack sufficient resources [41].

Pesticide trade in violation to the special decree No. 20/1990 [14,42] and the uncontrolled illegitimate usages of organochlorides on food crops in small scale irrigated farms, SSIF [1] showed how vast the problem is. Absence of a responsible institution, particularly in SSIF and large-scale open farms for training provision [1]; contributed to the unsafe pesticide handling, management, and potential for pesticide exposure.

Among the list of registered pesticides released by Ethiopian pesticides control board in 2017, 22% were in highly hazardous group and ~ 2.7% were with no human health hazard statements (Margaret et al., 2018). This is mainly attributed to poor implementation of pesticide legislations. Huge amount of obsolete pesticide stocks and prolonged storage, inappropriate storage conditions [43,42] also displays the governments' pesticide handling inefficiency. Unnecessary and too many donations by NGOs and procuring excess pesticides by the government resurges the accumulation of obsolete pesticides [12]. Obsolete pesticide stalks increased from 426 tonnes in the year 1995 to over 1500 tonnes in 1999 mainly owned by agricultural sate-farms and held by Ministry of health [41]. Recently, Ethiopia is one of the countries in Africa where largest accumulation of obsolete pesticides is found (Mengistie Belay, 2016). Cheap, locally produced pesticides that would be illegally elsewhere have led farmers to develop their own pesticide "recipe". Mixed use of Malathion and DDT is the aforementioned example [44] in Ethiopia. This is true currently in all irrigated vegetable production areas of the country, and especially of the central rift valley. Currently, increased frequency of pesticide application might be due to the ease accessibility of this obsolete pesticide stalks.

Significant tradeoff is also observed in chemical registration and use in Ethiopia. Both trade name and common name are used in Ethiopian registered pesticide lists. However, pesticides with the same active ingredients (a.i) are redundantly registered with different trade names and only their trade names are familiar for most of the end users which might be attributed to lack of awareness. For instance, Metalaxyl + Mancozeb, a fungicide used to control late blight of tomato has eighteen different trade names (MoNR, 2020). This indicates the probability of erroneous use of a single fungicide throughout a season to control late blight as a result of different trade name for farmers during shopping. This results an increased pesticide application frequency which increased pesticide risks on human and environmental health. In developing countries, intensive agriculture development and its potential negative effects on health lacks due attention (Martin, 2008) to be the of issue of their policy implementations. However, agricultural development policy and potential consequences of implementing intensive agriculture are part of the agriculture development sector, two sides of one coin (**Fig. 1**.) This figure depicts how labor productivity will be affected by health problems raised from the use of agricultural pesticides to increase agricultural production and productivity and any policy and its implementation should be sound without the violation of their (pesticide and labor) interdependency.

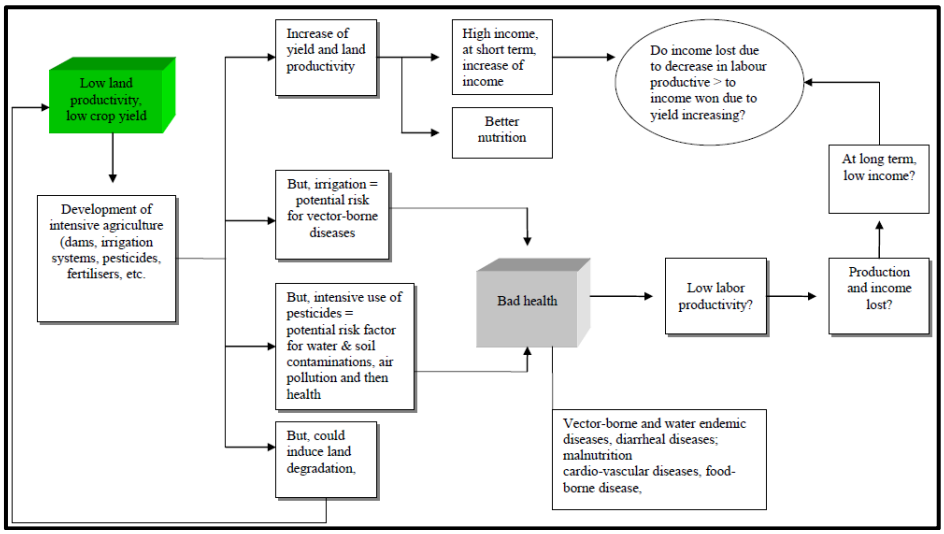

Fig. 3.The role of health in the cycle of poverty (Martin, 2008)

4.2 Lack of Awareness (Knowledge Gap)

Chemical pesticides, regardless of their inherent hazards, are intensively used in the fast-changing agriculture in Ethiopia. Smallholders are the major actors in the Ethiopia agriculture and produce the lion share, about 95% of crops produced every year [6]. Inadequate awareness of smallholders about the specific risks of pesticides on human health and environment and the necessity of using protective clothing and correct dosages [22,45,46] poses pesticide risk. Poor attainment of formal pesticide-related training; poor pesticide management, disposal; and limited use of complete Personal Protective Equipment (PPE) are the major problems in all farming systems; and particularly, in small-scale irrigation farming of the country [47]. Many farmers handle, apply, store and dispose of pesticides in ways that expose themselves, their families and sometimes consumers to serious risks [48]. Majority of pesticide spraying farmers in Ethiopia store pesticides at home, even in their living room [3]. Besides, empty containers are not properly disposed; instead, they served for domestic purposes to store food items, water, kerosene, and sometimes oil and local drinks and others are thrown at the edge of the field and riversides [45,41], Mengistie Belay et al 2017; [1].

Most farmers have no prior knowledge, skill, experience and training to be full-fledged practitioners in pesticides. A cross-sectional pesticide knowledge, attitude and practice assessment [1] indicated that 85% of workers did not attain any pesticide-related training, 81% are not aware of modern alternatives for chemical pesticides and 62% did not usually shower after work. According to Damte Tebkew and Tabor Getachew [45], 72% of vegetable growers in the central rift valley do not use PPEs while spraying pesticides. Fifty percent (50%) of smallholder farmers in the central rift valley of Ethiopia did not think of any pesticides harm to human health [3]. Self-reported risky handling and storage techniques, such as applying pesticides to human hair or skin to treat lice or open wounds [49]; washing pesticide-contaminated work clothing, using insecticides for home 'remedies' to treat headlice, fleas and bedbugs, and even to try and cure open wounds, using malathion or DDT [48] indicated how lack of awareness of pesticide is alarming in the country. In rural irrigation villages of Jima zone, southwest Ethiopia, ingestion (88.9%) and inhalation (90.4%) are reported as the major routes of pesticide exposure [23]. Nearly all the farmers in the Hawassa City Administration did not use any means of PPE, and the lack of awareness about the dermal route presented a high risk of exposure [47]. This indicates how poor attitudes of PPE use by farmers is a risk factor to pesticide related health problems. In the contrary, farmers having positive attitudes towards safe use of pesticides are still exposed to pesticides related health risks as they are not fully practicing this attitude, e.g., low use of PPE [23].

4.3 Gender and Childhood

Gender matters on the level of pesticide hazard. Social and biological factors determined the level of exposure to toxic chemicals and the resulting impact on human health [50]. For instance, men

in developing countries may be at higher risk of direct exposure to the chemical pesticides during application, while women and sometimes, children may be more likely to be indirectly exposed during planting and harvesting [51]. Employees of the floriculture industry in Ethiopia are mainly females and children as they are efficient in the greenhouse work which is the most vulnerable place for many pesticide exposures. At the same time, biological factors, notably, size, physiological, hormonal and enzyme differences between women and men, between adults and children as well influences susceptibility to health damage from exposure to toxic chemicals. According to studies conducted in Ethiopia (Sisay *et al*. 2020), Children ≤ 2 years old have higher average daily exposure when exposed to the same concentration of contaminant via inhalation. Hence being a female and child by itself exposes these groups of peoples to a significant level of pesticide risk. Lack of knowledge, low-risk perception, poverty and lack of decision-making power, even on matters relating to their own health are factors to health and environmental hazards of pesticide [50]. High poisoning rates among women (51%) and children of 5-14 years old (20%) of hospital records of the Amhara Regional Health Bureau in 2001, even though pesticides are almost exclusively sprayed by men in Ethiopia [48] indicates how being female or child will signify the problem. The odds of the knowledge concerning proper pesticide handling in Ethiopia positively influenced by the factor of age, access to training; and years of experience; Field practices adopted by farmers were disappointing and intentional suicide incidents among teenagers were the result of farmers' unsafe.

Storage [47]. The existing gap (inequality) of men in many aspects of agricultural development in developing countries leads females to be more exposed to agro-chemical toxicity.

4.4 Low Adoption Rate of IPM Technologies

One of the ways to reduce pesticide related risks is through integrated pest management [52]. Low adoption rate of integrated pest management (IPM) technologies by smallholder farmers also accounts for negative impact of pesticides on the human and environment. Even though, there is an improved level (50-60%) of adaptation in the floriculture sectors [13], this is associated with a strong market incentive (to comply with strict regulations on the EU market related to the type and quantity of chemicals). On the other hand, ill taxation of foreign available IPM-compatible chemicals, forced smallholders to use broad-spectrum pesticides.

4.5 Intensity of Pest

Intensity of pest severity warrants heavy use of pesticides [42]. A number of new insect pests, disease causing pathogens and weed species have set foot in the country and got established (Table 1).

Table 1. List of new emerging and re-emerging pest problems in Ethiopia

No.	Pest		Crop
	Common name	**Scientific name**	
1	Mealybug	*Phenacoccus sotenopsis*	Cotton
2	South American tomato moth	*Tuta absoluta*	Tomato
3	White mango scale	*Aulacaspis tubercularis*	Mango
4	Maize lethal necrosis disease	-	Maize
5	Root rot	*Sclerotium cepivorum*	Garlic & Onion
6	Bacterial wilt of ginger	*Ralstonia solanacearum*	Ginger
7	New races of wheat stem rust	*Puccinia graminis* f. sp *M id*	Wheat
8	Parthenium weed	*Parthenium hysterophorus* L	-
9	Water hyacinth	*Eichhornia crassipes*	-
10	Mesquite	*Prosopis* juliflora	-
11	Crenata broomrape	*Orobanche crenata*	Faba Bean
12	Witchweed	*Striga hermonthica*	Sorghum
13	Fall army worm	*Spodoptera frugiperda*	Maize, sorghum, wheat etc.
14	Stemphylium leaf blight	*Stemphylium vesicarium*	Onion

Source: [6,52,53]

5. FUTURE DIRECTION

Changing the above stated pesticide risks governing factors (negative energy) in to positive energy needs to be the emphasis of any stakeholders either private or governmental to reduce the health and environmental hazards from pesticides. Accordingly, the following issues should be considered for the safe and appropriate use of pesticides in the country.

5.1 Harmonized Agriculture Development Policies (HADP)

Ethiopian agriculture is the basis of its economy where more than 82% of the populations are engaged in [55] and generate income for their livelihood and the government of Ethiopia devices policies and strategies for this sector improvement. Growing the import and use of pesticides for its intensification to end with increased food production and expanding the floriculture industry and investment is part and parcel of these policies. However, increasing farm productivity and copping the associated health risks and enforcing/dictating its implementation (HADP), pivotal to increase productive man power and reduce health and environmental pesticide risks is missed. Pesticide legislations should be led by a state of art principle, e.g., using model-based risk assessment [26] and devising the legislation accordingly. Toxicity-weighted taxes i.e., tax as an absolute sum per unit of toxicity-weighted ingredient supplemented with “polluter pays” principle, experienced in UK is the other model to HADP. This is a principle of taxation by which the amount of tax to be paid will depend on weight of toxicity. Each of which are important to substitute the more toxic substance to less toxic one resulting in reduced overall toxic impact of pesticides and to internalizing social costs of pesticides use viz. adding the human and environmental health costs to the price paid by consumers [56], respectively.

5.2 Capacity Building

Increasing the capacity (staff power and physical) for full implementation of the rule and regulations of judicious use of modern agricultural development technologies and management needs a comprehensive effort involving many actors; environmental authorities, suppliers, NGOs, social and technological innovations [57]. Introducing new tools and techniques to set pesticide legislation by itself will not reduce pesticide related health and environmental hazards. Hence these tools and techniques with greater reliability to show the negative impacts of pesticides need to be employed by pesticides regulatory section so that every entity in pesticide value chain would be aware of it.

Farmers, who are the main end users and possibly, the first risk takers of pesticides, need to have improved knowledge. Lack of formal training on pesticide use and the failure to read pesticide labels have found to be the leading factors for having possible poor attitude and practice of pesticide usage in Ethiopia. Hence, farmers are using it indiscriminately and inappropriate, using unsafe pesticide handling, storage practice, ignoring risks and safety instructions [58,59]. Enhancing the level of the farmer’s knowledge through training, and information dissemination in workshops [59] is helpful.

On the other hand, capacity building is not only in the essence of restricting production and import of stringently toxic pesticides, increasing pesticide safety awareness, their proper use, implementation of personal protective measures, and awareness of good practices. It is also to attract and replace the demand and dependency of pesticide user in agricultural production with other solutions. Regulation and adoption of bio-pesticides need to insure to that introduced natural enemies would not become agricultural pests [56]. Hence capacity building needs to be holistic and comprehensive to reduce pesticide risk.

5.3 Non-chemical Pest and Vector Management

Using crop protection practices which are built on good agronomic practices, crop rotation and intercropping, the use of organic manures, resistant varieties and bio-control [60] as a part of sustainable development have to be a national pest management policy and a viable research agenda in the country. For example, introducing and promoting an increased use of integrated pest and vector management in the agriculture [61] is principal resort to reduce the reliance on pesticides that best led to reduced human health and environmental hazards.

5.4 Gender and Children-sensitive Educational Programs

Educational curricula of Ethiopia are known to promote the principle of educating females for

country development. However, only 30 percent of the total university joining students are females of which only one fourth are able to complete their studies [62]. Comparing to their increased number of employments in agriculture, especially, in the floriculture industry where huge (80 %) of the total job employment (180,000) are females [63], it is not difficult to imagine how small female agriculture employees are educated indicating how gender sensitive education is central to reduce the health and environmental hazards of agricultural pesticides.

Children are the other group of social entities which in one or the other way are dependent on the life of their maternities, especially of developing countries like ours. Hence, the number targeting females and children in education is a basic tool to reduce their exposure associated with agricultural pesticides. Pesticide's safety awareness, proper use of pesticides, and implementation of personal protective measures to decrease the pesticide exposure risk of women farmers and children in advance is key at work places.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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