ANNEX 4
RAPID RISK ASSESSMENT of PESTICIDES used by rural communities in AFRICA

ANNEX 4A
Rapid Risk Assessment of the use of Ridomil by rural communities in the Mbeya region, Tanzania

Ian, F. Grant

This RRA was carried out to assess the risks specific to the particular formulation(s) of Ridomil at the use rates identified by the community survey in Mbeya region, Tanzania and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

The RRA has been carried out assuming normal use rates for Ridomil. The survey of Mbeya suggested that certain pesticides were sprayed 11-52 times per year and, given that Ridomil was one of the pesticides used by many households it may fall into this category. However, data on specific pesticide use rates is lacking from the survey and thus attempting to quantify frequency of application for any given pesticide is impossible. Nonetheless, it should be recognised that IF applied at these high frequencies the environmental risks will be increased.

NB. It is vital that the specificity of this RRA to identified use in Mbeya is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

RIDOMIL (Product names: Dithane, Dithane 45, Farmerzeb, Ivory, Mancozeb)

Fungicides containing mancozeb (high %) and metalaxyl
Formulation: WP – also dust, liquid, granular

The pattern of use of Ridomil is as a general purpose fungicide, applied at a frequency of 1-3 times per crop to protect against mildews, spot, scab and blight. The recommended dose is 2.5kg ha^{-1} or 0.25g per m^2. Assuming 50% hits the target then 125mg m^{-2} may be deposited on the soil surface per application. In wet season, moist soils, tropical temperatures and high irradiance will accelerate degradation of both compounds, resulting in a half life of days. Ethylenethiourea, ETU, a contaminant and breakdown product of mancozeb, is more persistent but is sparingly soluble in water and unlikely to infiltrate groundwater. However, low ppb concentrations have been found in groundwater (1 case in 1600). Once in water the degradation is rapid. Metalaxyl is v.soluble in water and thus prone to horizontal and vertical transport (leaching), but it breaks down rapidly and in surface waters is not a threat to wildlife.

Knap sack sprayers generally deliver a range of large droplets (not aerosols), reducing the risk of airborne transport to water. Run off in water and soil particles after heavy rainfall could result in its deposition in surface waters (furrows, pools, streams) but degradation would be rapid.

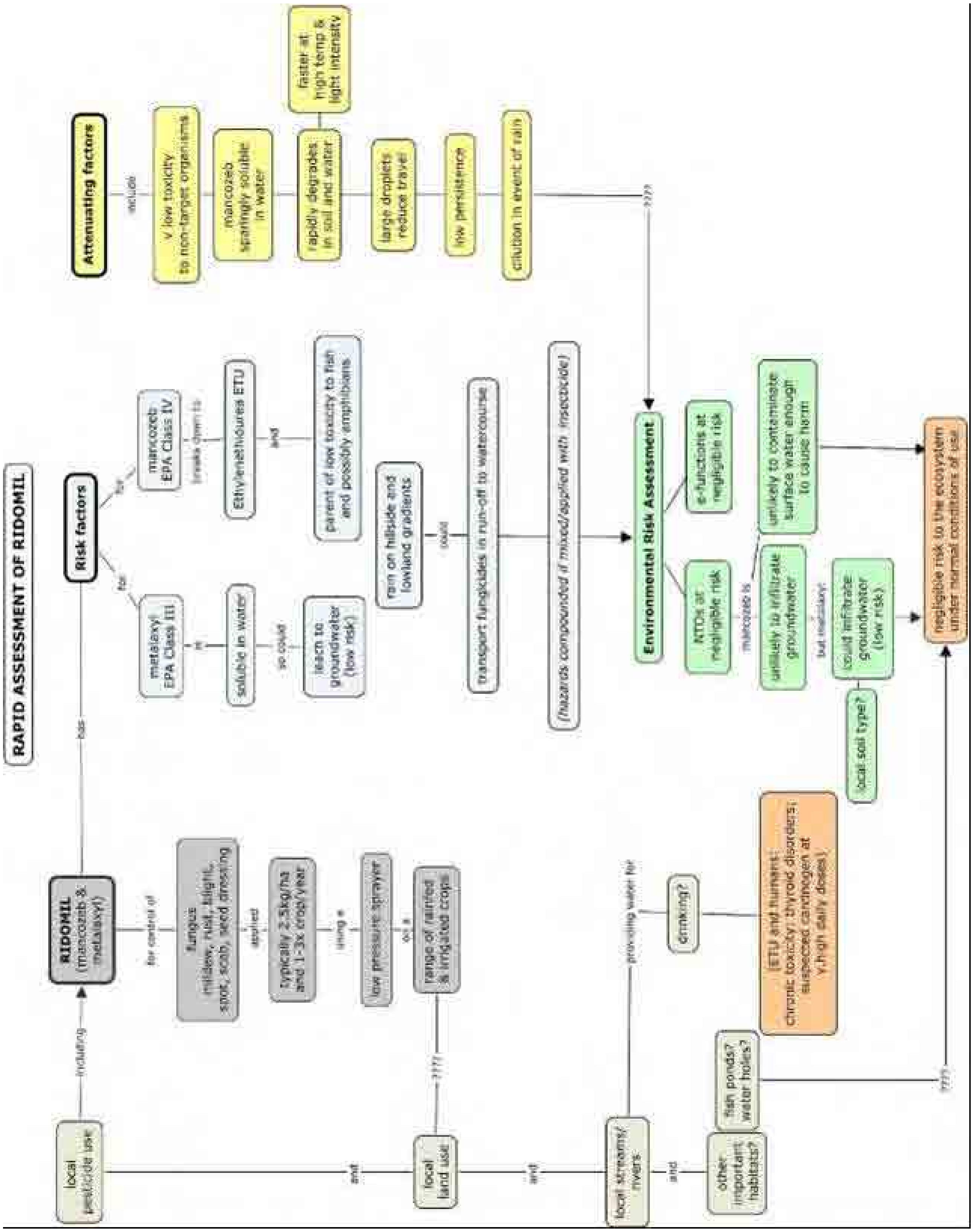
The low toxicity of both compounds to wildlife and their rapid degradation rates in water and soil virtually eliminates all risks of harm to terrestrial and aquatic vertebrates and invertebrates. Fish are vulnerable at low ppm levels of mancozeb, but under normal use these levels would not be attained. Farmers indulging in poor practices – such as washing out their spray tanks in a pond or stream would still be unlikely to raise the concentration in water to levels that cause mortalities of fish.or amphibians. Ridomil used as a seed dressing poses no threat to birds. Soil functions such as OM breakdown and nutrient recycling are unlikely to be at risk from Ridomil use.

There is no information given about the wider receiving environment. But one can surmise that as Ridomil is used as a crop protection agent, its use is restricted to farms and small plots. Transport from the crop environment to natural habitats or other farming systems (e.g. aquaculture) is improbable, given the scale and method of operations.

Risk Management: judging from survey returns:

- improvements indicated re. disposal of spent containers – and re-use of empty containers that appear to be used as food/water storage I small % of cases
- need for further education over use of protective clothing – signif. % spraying in normal clothes, bare hands and feet etc
- not all farmers read, heed instructions on canister or wind direction
- poor storage conditions – most in house for security
- some use old and obsolete pesticides
- alternatives to pesticides could be promoted
- positive results from pesticide not always recorded. Is it necessary to spray. Is it economic to do it with such frequency. Don't contaminate soil and water unnecessarily

Rapid Risk Assessment of Ridomil



ANNEX 4B

Rapid Risk Assessment of the use of Selecron by rural communities in the Mbeya region, Tanzania

Ian, F. Grant & Colin C.D. Tingle

This RRA was carried out to assess the risks specific to the particular formulation(s) of Selecron at the use rates identified by the community survey in Mbeya region, Tanzania and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

The RRA has been carried out assuming normal use rates for Selecron. The survey of Mbeya suggested that certain pesticides were sprayed 11-52 times per year and, given that Selecron was one of the pesticides used by many households it may fall into this category. However, data on specific pesticide use rates is lacking from the survey and thus attempting to quantify frequency of application for any given pesticide is impossible. Nonetheless, it should be recognised that IF applied at these high frequencies the environmental risks will be increased.

NB. It is vital that the specificity of this RRA to identified use in Mbeya is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

RAPID RISK ASSESSMENT

SELECRON (Profenofos)

Selecron® or profenofos is a broad spectrum organophosphorous insecticide/acaricide used to control insect pests and mites in crops. It is registered as a general purpose insecticide in Tanzania to manage pests of coffee, cotton, vegetables and cashew. Classified by WHO as a Class II compound (moderate toxicity), its mode of action is neurotoxic, and acts as a cholinesterase inhibitor. This mode of action puts all non-target vertebrates and arthropods at some risk, depending on the mode and degree of exposure. Profenofos is not listed as teratogenic, carcinogenic or mutagenic, or is known to have reproductive effects or cause endocrine disruption**.**

At manufacturers' recommended rates, between 0.5 and 1.2kg ha^{-1} is applied in accordance with crop and pest type[1]. Repeated applications in the growing season of the Mbeya region are common: - from 3 (66% of respondents) to 12 (33%) times, depending on the severity of infestation. Farmer habits and cost are factors in deciding frequency and dose. Assuming 50% of the compound hits the target, then between 0.75 and 7.2 kg ha^{-1} $crop^{-1}$ could be deposited on the soil. Run off from crop foliage may increase the soil burden, although degradation is rapid in soils of pH>7.0. There are no statistics on the area (km^2) over which it is applied in Mbeya.

The dissipation and degradation rates of profenofos in the tropics are rapid, especially in neutral to alkaline soils, with a half life of <2-3 days, but this is extended in neutral to acid soils of the type widely encountered in the Mbeya region. Profenofos is not persistent in soil, water or sediment (anaerobic breakdown is slower than aerobic). The mobility of profenofos in soils is reduced because of it low solubility in water and its affinity for soil organic matter. It is therefore not expected to leach to groundwater. Soil residues in tropical vegetable plots ranged from 0.01-0.02 ppm from normal use of profenofos, and leacheate and run-off concentrations were in low ppt. One of the major degradates, 4-bromo-2-chlorophenol, is persistent in the environment while the fate of another degradate, O-ethyl-S-propyl phosphorthioate, is not well known. Neither pose any toxicological problems.

Rapid breakdown rates reduce the impacts of Selecron on soil fauna, flora and functions as exposure is minimized. Soil microbes soon recover from any initial depression after spraying. Repeated spraying is likely to suppress populations of epigeal fauna (beetles, bugs, crickets and spiders etc). Some bird species may be susceptible – chronic exposure through ingestion of contaminated insects or berries could affect fecundity (egg production observed in laboratory quail). Bees and pollination are at medium risk from the use of Selecron – through the route of contact with flowers rather than contact with droplets. Aquatic fauna (fish and invertebrates) are at most risk from run-off and drift of Selecron droplets. Its use near water (riparian farms) increases the likelihood of contamination and the exposure of aquatic organisms. Run-off from fields to gulleys and streams is the most likely route of exposure, since low pressure sprayers reduce the likelihood of droplets becoming airborne. Given the low solubility of selecron in water and its affinity for organic matter in soil and sediment (adsorption), the bioavailability of the chemical is significantly reduced. Greater protection of aquatic spp is afforded by streams and rivers with suspended sediments.

Results of lab-based acute toxicity studies are not representative across all species of non-target organisms. Species react very differently to toxins; exposure to toxins varies by crop and application method, and environmental parameters such as temperature and soil type

[1] n.b. farmers do not always comply with the recommended dose rates

affect the availability of properties of toxins. Aquatic species are at most risk. Field studies show that fish exposed to profenofos from use in cotton fields (6x per season) have reactions ranging from raised AChE[2] activity to mortality (13 significant fish kills). The fish kills were mostly attributed to run-off, and suggests that mortality of aquatic invertebrates, which are equally or more sensitive than fish, is also likely.

In the Mbeya region, Selecron is used by nearly half of all households and 9% of all fields are riparian and 50% lowland. Surface water adjacent to cotton, coffee and vegetable fields is at some risk of pollution from pesticide run-off. Acid soils in the region will slightly extend the longevity of the active ingredient (i.e. persistence) in soil and water. Multiple applications every season, year after year, present a risk of chronic exposure to fish and aquatic invertebrates. Only ecological monitoring in the villages could determine the effects of gradient and seasonal rainfall on run-off, and the ameliorating effects of dilution and suspended solids in the rivers when they are at their highest levels. Many of the small streams and rivers will cease to flow in dry season, resulting in widespread mortality and movement of species out of the area.
If ULV formulations of Selecron are used in Mbeya (not indicated in the survey), then bees and pollination are at high risk from drifting aerosols.

Many users of pesticides in Mbeya spray mixtures of pesticides. This may be simultaneous or consecutive use. These practices may increase the risks to non-target organisms and ecological functions through potentiation of toxicity (synergistic effects of combined use).

[This rapid risk assessment does not embrace human health and safety]

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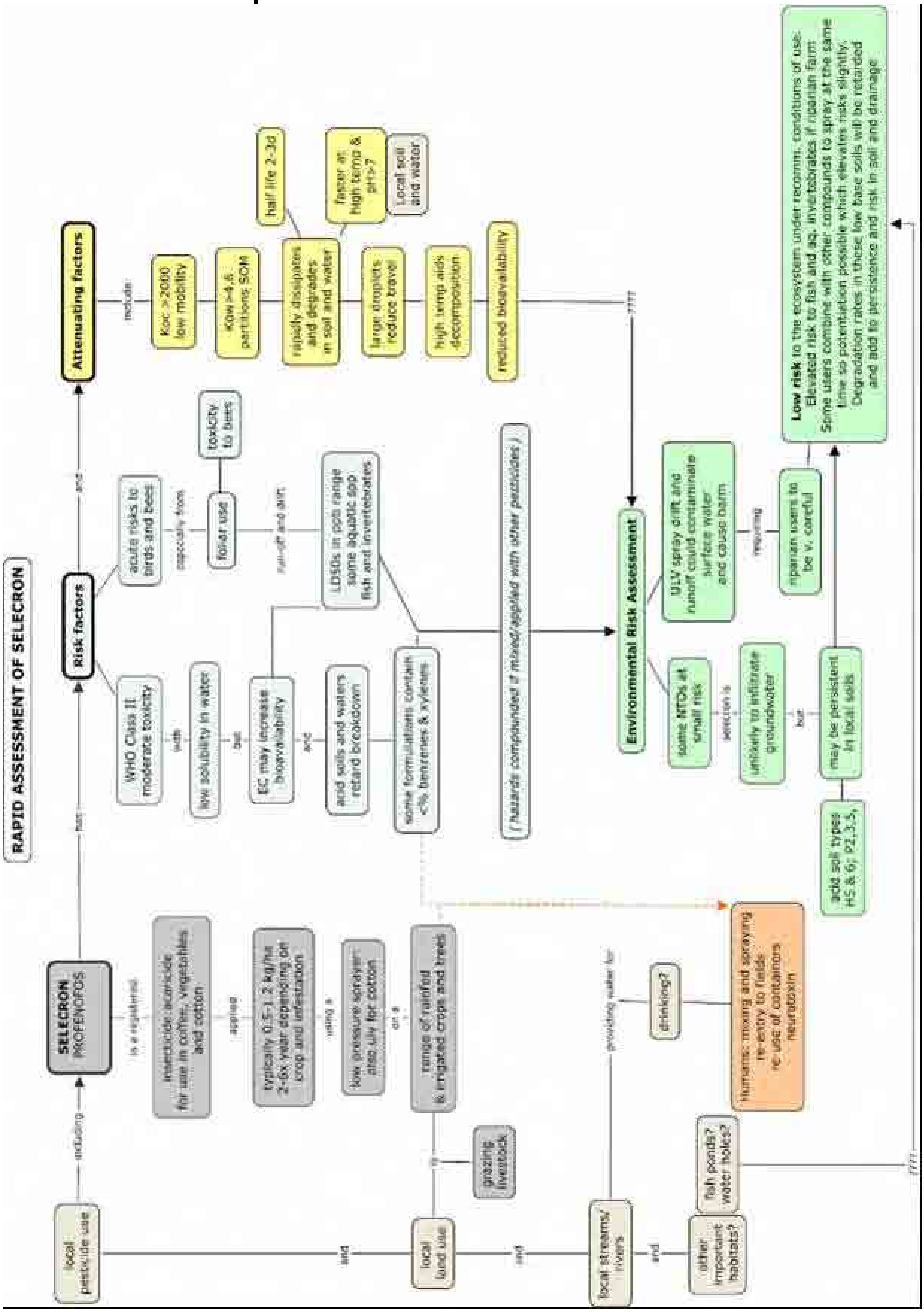
[2] acetylcholinesterase

Rapid Risk Assessment of Selecron



ANNEX 4C
RAPID RISK ASSESSMENT OF 2,4-D Amine USED BY RURAL COMMUNITIES IN MBEYE REGION, TANZANIA – Ecotoxicity (& Human health risks)

Colin, C.D. Tingle & Ian, F. Grant

This RRA was carried out to assess the risks specific to the particular formulation(s) of 2,4-D Amine at the use rates identified by the community survey in Mbeya region, Tanzania and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

The RRA has been carried out assuming normal use rates for 2,4-D. The survey of Mbeya suggested that certain pesticides were sprayed 11-52 times per year. However, data on specific pesticide use rates is lacking from the survey and thus attempting to quantify frequency of application for any given pesticide is impossible. Nonetheless, it should be recognised that IF applied at these high frequencies the environmental risks will be increased.

NB. It is vital that the specificity of this RRA to identified use in Mbeya is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

2,4-D Amine (Product names: Herboxone and many others)

Herbicide containing ACTIVE INGREDIENT:
Dimethylamine salt of 2,4-D-Dichlorophenoxyacetic acid ………….…….. 46.3%
INERT INGREDIENTS: 53.7%
Formulation: Commercial 2,4-D herbicide formulations considered here consist of the more soluble amine salts.
In Tanzania, emulsifiable concentrate (EC) seems to be the commonest formulation

Rapid Risk Assessment

The pattern of use of 2,4-D is as a general purpose herbicide, but herbicides are a relatively minor component of pesticide use in the communities sampled (about 5.5% of respondents to the questionnaire). Thus, herbicides represent a low risk to the environment simply because their use is very limited. Of the herbicides used by the communities, 2,4-D was the most common (about 4% of pesticide users).

Environmental risks

Usually applied just once (it is unclear from the survey what the application frequency was in Mbeya) for control of a variety of broad-leaved weeds. Assuming recommended rate of application: 1.1-2.75 l/ha (for a 470 g/l formulation).

Assuming that 50% hits the target weeds, then 258.5-646.25 g ha^{-1} or 26-65 mg per m^2 may be deposited on the soil surface.

Given that 60% of farmers could not guarantee that they followed instructions, it is necessary to increase this range in both directions. Thus, assuming that a 50% error in dose rate could be made in either direction, then from 13-130 mg m^{-2} will end up on target weeds and the same quantity will be deposited on soil.

At these levels, there is a clear risk to non-target terrestrial, broadleaved vegetation in the locality of 2,4-D applications. Some legumes are particularly sensitive. This may provide a low level of risk to beneficial activity of certain natural enemies of crop pests. Ladybird beetles (Coccinellidae) are particularly sensitive. Without more detailed information on vegetation composition in the location, any risk of indirect impact to non-target invertebrates of effects on broad-leaved plants is impossible to quantify.

In wet season, with moist soils, tropical temperatures and high irradiance will accelerate degradation, resulting in a half life of a few days. Risks to soil algae and fungi are thus likely to be low and short lived. Similarly for any surface active or soil invertebrates. Soil functions such as organic matter breakdown and nutrient recycling are unlikely to be at risk from 2,4-D use and any effect would be localised.

Without specific information on bird fauna and abundance in the study area, risks to birds are impossible to quantify. However, given the identification of low-moderate risk to certain birds in the Risk Assessment carried out for Washington State, USA, a similar level of risk is unlikely for Mbeya, simply bcause of the low levels of application on an area basis.

Toxicity to mammals from 2,4-D Amine is higher than that to birds. Also, some mammals are very susceptible to changes in vegetation. Thus, again based on the Washington State RA, low risk to small rodents and possibly other small mammals would be a possibility, were the areas subject to treatment not so small.

Knap sack sprayers generally deliver a range of larger droplets (not aerosols), reducing the risk of airborne transport to water. Run off in water and soil particles after heavy rainfall could result in some deposition of 2,4-D Amine in surface waters (furrows, pools, streams) but degradation would be fairly rapid. At the very low levels likely from this, risks to aquatic wildlife are very low (even to those fish and aquatic invertebrates which are sensitive to 2,4-D).

Farmers indulging in poor practices – such as washing out their spray tanks in a pond or stream would clearly raise the concentration in water and thus the risk to aquatic wildlife. However, risk of significant mortalities of fish or amphibians is still, probably, relatively low and short-term.

There is no information given about the wider receiving environment. But one can surmise that as 2,4-D is used as a crop protection agent, its use is restricted to farmlands and small plots. Transport from the crop environment to natural habitats (other than waterways – see above) or other farming systems (e.g. aquaculture) is improbable, given the scale and method of operations.

Human health risks

Given the levels of poor understanding of pesticides and poor pesticide management uncovered by the survey, it is clear that there is a significant risk to those who use and apply (as a spray) 2,4-D Amine. Eye and skin irritation are high risk; coughing, diziness, lack of co-ordination, weakness, fatigue and possibly nausea are all also likely in those applying the herbicide. Irreversible eye damage can occur from the amine salt. Liver, kidney and nervous system disfunction is a risk from prolonged exposure. Birth defects and cancer are low risk, but evidence on the latter is uncertain. A precautionary approach is recommended (i.e. avoid use).

Risks to villagers in general is relatively low, given low use rates within the community. Thus even if waterways used for washing or drinking water are contaminated, risks to village population is relatively small (but undoubtedly present!). Nonetheless, given the very low MCLGs recommended by the US EPA, it is possible that these may be exceeded for short periods.

Domestic dogs are at moderate risk of health effects (even mortality), if they come regularly into contact with the herbicide.

Risk Management: judging from survey returns:

For environmental protection
Provide training/awareness raising on

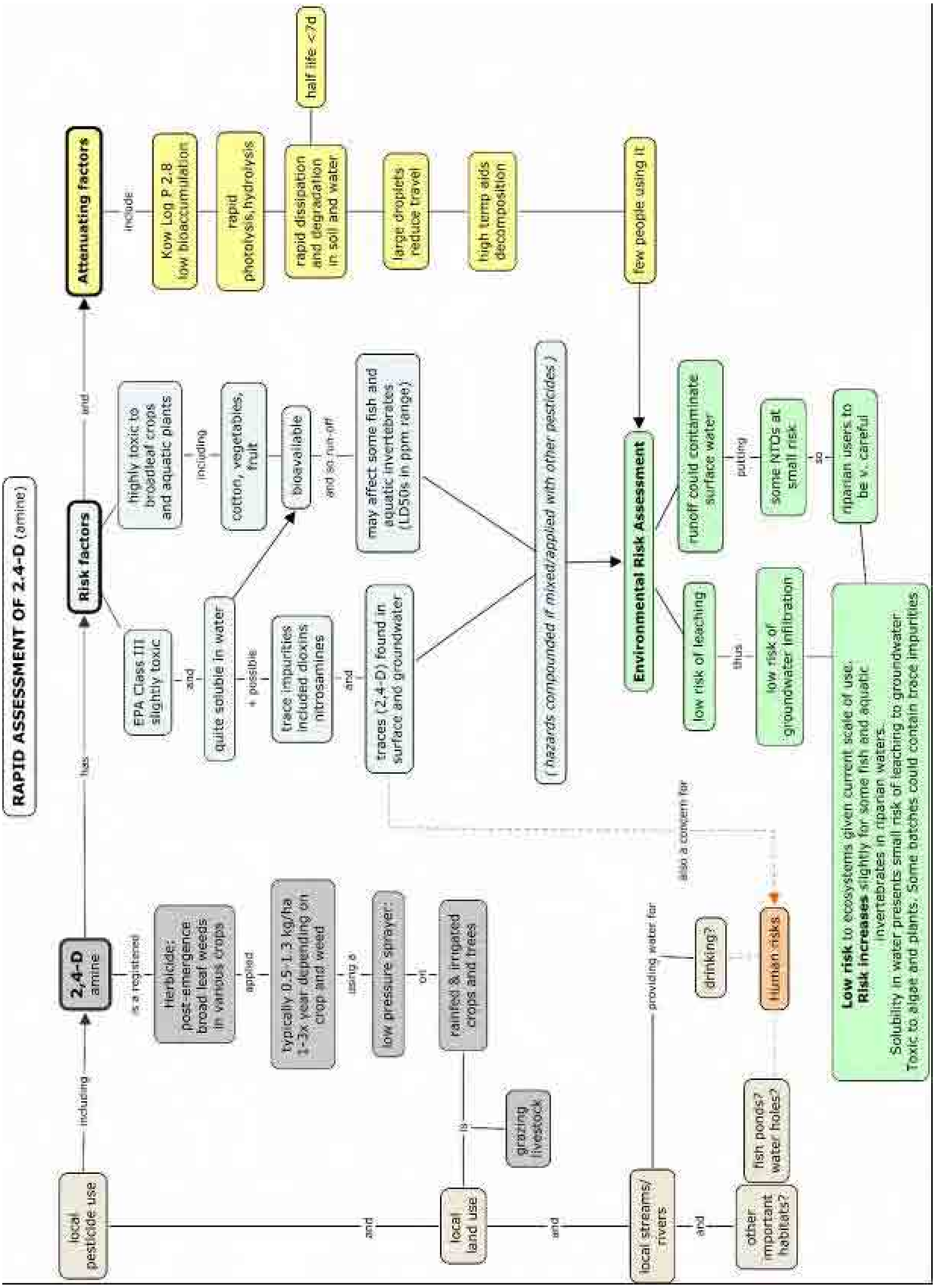
- the importance of all farmers reading, heeding instructions on pesticide containers/packaging
- all farmers taking heed of wind direction and other weather conditions which affect fate of pesticides
- dangers from use of old and obsolete pesticides
- alternatives to pesticides for crop protection and livestock care
- assessment of benefits vs risks from pesticide use (given the fact that positive results from pesticide use was not always recorded by the survey). Is it necessary to spray? Is it economic to do it with such frequency?
- Avoiding unnecessary contamination of soil and water by pesticides

- Importance of reporting environmental incidents potentially resulting from pesticide use

For human health
Provide training/awareness raising on

- correct disposal of used/empty pesticde containers (given reported re-use of empty containers as food/water storage in small % of cases)
- use of protective clothing when handling and applying pesticides (– signif. % spraying in normal clothes, bare hands and feet etc.)
- the importance of reading and heeding instructions on pesticide labels/packaging and NOT using unlabelled pesticides or those with instructions in a foreign language
- storage conditions for pesticide safety with an emphasis on risks to children (NB. Survey showed most stored in house for security)
- health risks from use of old and obsolete pesticides
- alternatives to pesticides for crop and animal health protection
- assessment of necessity (costs/benefits) of pesticide use. Is it economic to do it with such frequency?
- Prevention of unnecessary contamination of soil and water and associated health risks

Rapid Risk Assessment of 2,4-D



ANNEX 4D
RAPID RISK ASSESSMENT for use of BLUE COPPER[3] /BLUE SHIELD (COPPER): COPPER HYDROXIDE **by rural communities in the Mbeya region, Tanzania**

Ian, F. Grant

This RRA was carried out to assess the risks specific to the particular formulation(s) of Blue Copper at the use rates identified by the community survey in Mbeya region, Tanzania and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

The RRA has been carried out assuming normal use rates for Blue Copper. The survey of Mbeya suggested that certain pesticides were sprayed 11-52 times per year. However, data on specific pesticide use rates is lacking from the survey and thus attempting to quantify frequency of application for any given pesticide is impossible. Nonetheless, it should be recognised that IF applied at these high frequencies the environmental risks from Blue Copper will be increased considerably as it accumulates and can affect soil function.

NB. It is vital that the specificity of this RRA to identified use in Mbeya is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

[3] There is no compound registered with this name in Tanzania. $Cu(SO_4)$ is also blue but is not registered for plant protection in Tanzania -,only as a wood preserver (against fungi and termites) when mixed with arsenic.

BLUE COPPER[4] **/BLUE SHIELD (COPPER)**: COPPER HYDROXIDE

RAPID RISK ASSESSMENT

Copper hydroxide $Cu(OH)_2$ use is registered in Tanzania as *Blue Shield* for use in coffee against coffee berry disease (CBD) and other fungal diseases. Copper oxide (parent species) is registered for CBD and late rust on coffee. Both are effective as fungicides to protect other crops. They are slightly hazardous compounds (WHO Class III) to humans. Other Cu compounds are registered but not reported as used in the Mbeya region.

Blue shield works as a contact fungicide and is applied as a spray (water dispersable granules or EC).

Dose rates recommended for CBD and other fungal diseases vary with product and formulation. For a typical 80% formulation of $Cu(OH)_2$, dose rates are 6-8 kg ha^{-1} at a frequency of 3-5 times a crop - as required. The apparent use in the Mbeya region is 3 spays per crop, i.e. 21 kg $Cu(OH)_2 ha^{-1} crop^{-1}$. If all the product were eventually to reach the soil[5], that would be equivalent to about 10.8kg Cu $ha^{-1} year^{-1}$. Repeated application year after year will cause a build up of Cu residues in the soil because they are not degradable.

As copper residues build up in soil they will affect the health of the soil. Copper originating from fungicide application reduces soil microbial biomass and has resulted in the elimination of earthworms in the orchards where residues averaged between 180-338 mg kg^{-1}. Copper is an abundant mineral and natural background levels of Cu vary widely with parent rock type but commonly average less than 25 mg kg^{-1} or 25 kg ha^{-1}[(6)]. The addition of 10.8 kg Cu residues $ha^{-1}y^{-1}$ will quickly elevate background levels. Significant Cu enrichment can be expected.

Copper hydroxide is insoluble in water but does dissociate at low pH (<6) and in sandy soils there may be potential for Cu to infiltrate groundwater. Coffee growing soils (Umbric Nitosols) of the wards surveyed are of low base status and require lime and organic matter to improve productivity. Their acid nature and poor OM status will encourage solubilisation of Cu and possibly reduce its capacity to bind Cu, but under coffee trees litter build up will increase adherence of Cu in the soil. Andosols of the region are also acidic but are not (ideally) used for coffee. Risks of Cu leaching and groundwater infiltration in these soils are v low.

Rainfall will transport Cu residues bound on soil particulates and OM from hillsides and low lying areas into watercourses. High concentration of Cu (from repeatedly sprayed areas) can be toxic to aquatic components of ecosystems, especially in more acidic waters where molluscs, crustaceans and fish are at some risk of harm. Dissolved organ carbon, suspended particulate matter and alkaline waters provide a significant measure of protection against harm. (My guess is that water is neutral to acidic from geology and soils (volcanic origin and low base status)). River sediments will provide a sink for Cu and be a threat to some benthic animals such as catfish and molluscs.

Acidification of the soil through the application of certain fertilizers, such as ammonium nitrate or sulphate will increase the availability of Cu for plant uptake and soil toxicity. Plants

[4] There is no compound registered with this name in Tanzania. $Cu(SO_4)$ is also blue but is not registered for plant protection in Tanzania -,only as a wood preserver (against fungi and termites) when mixed with arsenic.
[5] Some will be removed in beans; some remains on leaves
[6] using 10cm depth over 1 hectare or 1 tonne of soil (if bulk density=1)

need trace amounts of copper for healthy growth. Many plants can withstand high levels of bioavailable Cu in soils.

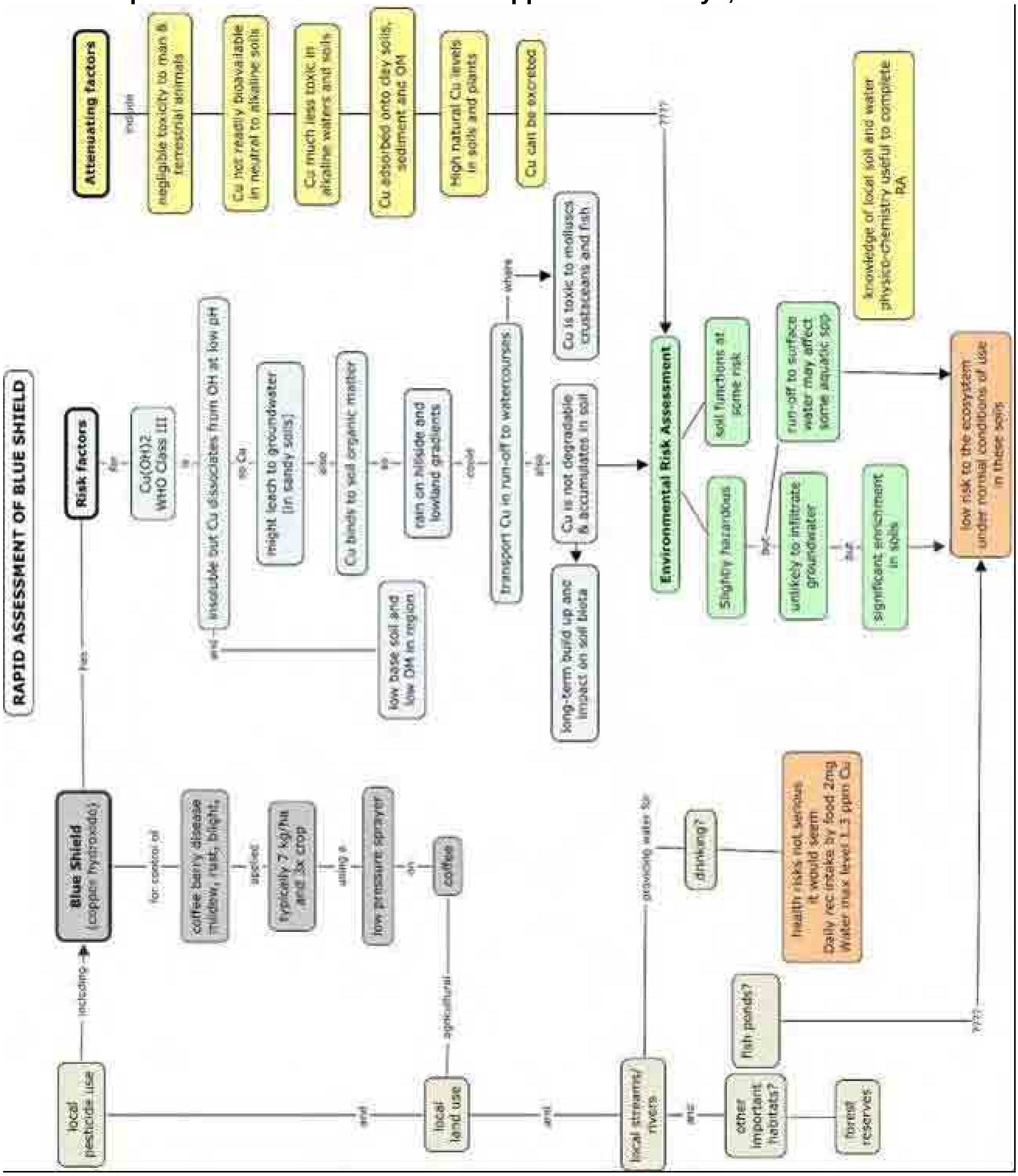
Health: Ubiquitous in nature, Cu occurs naturally in many foods at significant levels and also in potable water. An essential element for life that can be excreted by the body. A single day's diet may contain 10 mg or more of copper. The daily recommended allowance of copper for adults' nutritional needs is 2 mg. In drinking water. EPA has recommended max contaminant level of 1.3ppm Cu. No cumulative effects are known.

Overall conclusion – $Cu(OH)_2$ use as a fungicide presents little risk to terrestrial and aquatic ecosystems in the Mbeya region. But continuous use will lead to the accumulation of Cu residues in soil and sediment and in acid soils leading to a decline in soil function (nutrient cycling). The use of fertilisers (manures, chemicals) will mask the impact of reduced soil functions.

Management notes: To reduce the rate of Cu enrichment in soil and transport of Cu to water, look for alternatives to Cu: either other chemical control (probably more expensive) or non-chemical options. i.e. IPM approach; resistant varieties/cultivars

Colletotrichum on coffee berries (CBD

Rapid Risk Assessment of Blue Copper use in Mbeya, Tanzania



ANNEX 4E
RAPID RISK ASSESSMENT OF 2,4-D USED BY RURAL COMMUNITIES IN THE RIFT VALLEY, ETHIOPIA – Ecotoxicity (& Human health risks)

Colin C.D. Tingle & Ian, F. Grant

This RRA was carried out to assess the risks specific to the particular formulations of 2,4-D at the use rates identified by the community survey in the Ziway and Arsi Negele regions of the Rift Valley, Ethiopia and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

NB. It is vital that the specificity of this RRA to identified use in Ziway/Arsi Negele communities is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

2,4-D (Product names: Agro-2,4-D Amine, Desormone, Zura Herbicide, U46 D Fluid 72% EC and many others)

Herbicide containing ACTIVE INGREDIENT:
Dimethylammonium salt of 2,4-D-Dichlorophenoxyacetic acid (most commonly); but the ethylhexyl [EH] (and other) esters are possible, amongst others

In Ethiopia, soluble liquid (SL) and emulsifiable concentrate (EC) are the 2,4-D herbicide formulations mentioned in the pesticide registration document. Eleven herbicides based on 2,4-D are registered in Ethiopia, but one of these is listed yet registration has expired.

The pattern of use of 2,4-D is as a general purpose herbicide and herbicides are a very major component of pesticide use in the Rift Valley communities sampled (almost 90 % of respondents to the questionnaire). Of the herbicides used by the communities, 2,4-D was the most common, along with U-46 (which we assume to be mecoprop). Thus 45% of pesticide users from the survey applied 2,4-D.

Environmental risks

Probably applied twice annually (the data from the survey on application frequency in Ziway and Arsi Negele waredas was not presented in the ISD report) for control of a variety of broad-leaved weeds. The recommended rate of application for 2,4-D in Ethiopia is unknown; however, studies have found between 0.46 l/ha and 3l/ha of 2,4-D being applied in Ethiopia.

Assuming that this constitutes the range of application rates for the study waredas in the Rift Valley and assuming mixing of SL or EC formulations as instructed on the label, then 331.2-2160 g ha^{-1} or 33-216 mg/m^2 will be released from sprays.

The survey could not collect data on the accuracy nor target coverage of pesticides applied. Thus, for the purposes of this RRA, if we assume that 50% hits the target weeds, then 165.6-1080 g ha^{-1} or 16.5-108 mg per m^2 may be deposited on the soil surface.

Given that about 70% of farmers could not guarantee that they followed instructions (and it is unclear from the results whether this includes those that are illiterate), it is necessary to increase this range in both directions. There is no data to provide any guide to the level of inaccuracy made by these farmers in terms of application rates, thus an assumption that a 50% error in dose rate (including dilution errors and application rate errors) could be made in either direction is used. This would mean that from 8-216 mg m^{-2} will end up on target weeds and the same quantity will be deposited on soil.

*NB. The **assumptions** made in arriving at this potential deposition rate for 2,4-D are **highly speculative** and no account is taken of the possibility that farmers may tend to under-dose (to avoid financial costs). Nonetheless, these deposition rates will be used as the basis for the following risk assessment, in the absence of accurate statistics*.

At the high end of these levels (>200 mg m^{-2}), there is clearly a high risk to non-target terrestrial, broadleaved vegetation in the locality of 2,4-D applications. Some legumes are particularly sensitive.

This, in turn, may provide a low-moderate level of risk to beneficial activity of certain natural enemies of crop pests. Without more detailed information on vegetation composition in the location, any risk of indirect impact to non-target beneficial invertebrates of effects on broad-leaved plants is impossible to quantify.

However, the direct risk of toxicity to surface active invertebrates (e.g. predatory beetles, millipedes) would appear to be low. Similarly for those species of parasitic wasps known to be sensitive to 2,4-D.

The risk to soil invertebrates, including some species of earthworms known to be sensitive to 2,4-D (e.g. *Eisenia foetida*) is low, given an estimated 2 – 4 ppm in the top 10 cm of soil.

There does not appear to be any risk of acute toxicity to bees, given that 0.094 mg/bee would have to be accumulated from flowers visited to reach the oral LD_{50}. However, quantifying the risk is difficult because data on the rate of accumulation of this concentration of 2,4-D is lacking. The risk to successful brood production in bees is also hard to quantify, despite knowing that 100 ppm 2,4-D reduces brood production by 98%, for the same reason. Also, this risk factor may be complicated by findings that low levels of contamination with 2,4-D can lead to enhanced brood survival.

In wet season, with moist soils, tropical temperatures and high irradiance will accelerate degradation, resulting in a half life of a few days. Risks to soil algae and fungi, if any, are thus likely to be short lived. Any risk to soil invertebrates will also be short lived.

There may be a high level of risk to nitrogen fixing bacteria associated with legumes that survive the application, as these have shown reduced numbers of root nodules on plants subjected to 1 ppm 2,4-D (may not be a problem is the legumes are weeds causing crop losses).

Soil functions such as organic matter (OM) breakdown and nutrient recycling are highly unlikely to be at risk from 2,4-D use and any effect would be localised.

Without specific information on bird fauna and abundance in the study area, risks to birds are impossible to quantify. Also, no data on toxicity to African bird species has been located. However, given the identification of low-moderate risk to certain birds in the Risk Assessment (RA) carried out for Washington State, USA, a higher level of risk has to be acknowledged for Ziway and Arsi Negele given the potentially high application rates and the wide-ranging use. There is also a relatively high risk of significant habitat alteration and effects on wild plants in and around sprayed fields, which could affect food sources for birds – both seeds for gramnivores and invertebrates for insectivores and omnivores. However, the range of bird species and abundance in the Rift Valley agro-ecosystems is likely to be very, very much lower than in woodland in Washington State; thus, on balance a low-moderate risk to birds is probable BUT this assumption needs verifying.

Toxicity to mammals from 2,4-D is of a similar order to that of birds. Thus, again based on the Washington State RA, low-moderate risk to small rodents and perhaps other small mammals is a possibility. This risk could also be excerbated by loss of cover (from plants being killed) and of food sources (as with birds). However, no data is available of composition and abundance of small mammal fauna in the ago-ecosystems to which the 2,4-D is applied in the Rift Valley communities under investigation and adverse impacts on small mammals in the USA has been highly species specific. The risk of chronic toxicity to jackals may also be moderate (if they frequent the areas around the surveyed villages), given the high sensitivity of dogs to 2,4-D.

Knap sack sprayers (of the type identified in the survey as being the most common spray apparatus) generally deliver a range of larger droplets (not aerosols), reducing the risk of airborne transport to water. Run off in water and soil particles after heavy rainfall could result in some deposition of 2,4-D in surface waters (furrows, pools, streams), but degradation would probably be fairly rapid. It is unlikely that this is likely to occur to any significant extent, thus risks to aquatic wildlife are likely to be negligible (even to those fish which are sensitive to 2,4-D; possibly low risk from the EH ester). Despite high susceptibility of pond weeds and certain other aquatic plants to 2,4-D, they are unlikely to be significantly disrupted by the very small quantities which seem likely to reach waterways from run-off.

NB. There is inadequate data on the distance of crop fields from the lakes (including the soda lakes) to make an assessment of the risk to this important habitat. Certainly, if 2,4-D were to get into these lakes in significant concentrations, then the risks to important wildlife would be high. The soda lake food chains are based on blue-green algae, which would be highly sensitive to 2,4-D.

Farmers indulging in poor practices – such as spraying adjacent to open waterways and/or washing out their spray tanks in a pond or stream would clearly raise the concentration in water and thus increase the risk to aquatic wildlife, but they are still likely to be in the low-moderate range (except from the EH ester, where risk could be high or even very high). Given the extent of usage of 2,4-D and poor training in pesticide management, risk of significant mortality of fish, amphibians and invertebrates is a possibility (particularly from the 2,4-D EH ester), but would be difficult to quantify without more hard data.

There is no information given about the wider receiving environment. But one can surmise that as 2,4-D is used as a crop protection agent, its use is restricted to farmlands and small plots. Transport from the crop environment to natural habitats (other than waterways – see above) or other farming systems (e.g. aquaculture) is improbable, but again, information is lacking on which to base any assessment.

Overall, it is difficult to generalise risks. However, it seems that most available formulations are of less toxic salts (not the generally more toxic acid) and above assessment implies negligible to low risk from use levels assumed. 2,4-D does not bioaccumulate, so this is not a risk. Mis-use may lead to low to moderate risk to both terrestrial and aquatic environments, depending on the form applied; the risk from the EH ester to aquatic ecosystems hay be higher with mis-use.

Human health risks

Given the levels of poor understanding of pesticides and poor pesticide management uncovered by the survey, it is clear that there is a significant risk to those who use and apply (as a spray) 2,4-D. Eye and skin irritation are high risk; coughing, diziness, lack of co-ordination, weakness, fatigue and possibly nausea are all also likely in those applying the herbicide. Irreversible eye damage can occur from the amine salt and risks from this should be taken seriously.

Liver, kidney and nervous system disfunction is a risk from prolonged exposure. Birth defects and cancer are low risk, but evidence on the latter is uncertain. A precautionary approach is recommended (i.e. avoid use) and use of protective clothing is important in reducing the risk where 2,4-D is used.

Risks to villagers in general is moderate, given high use rates within the community. Thus waterways used for washing or drinking water are at distinct risk of becoming contaminated, and the risk of minor chronic health problems (and possibly acute problems, particularly to eyes) within the village population is undoubtedly present. Given the very low MCLGs recommended by the US EPA, it is possible that these may be exceeded for short periods.

Domestic dogs are at moderate risk of health effects (even mortality), if they come regularly into contact with the herbicide, particularly when it is stored in parts of the home accessible to dogs.

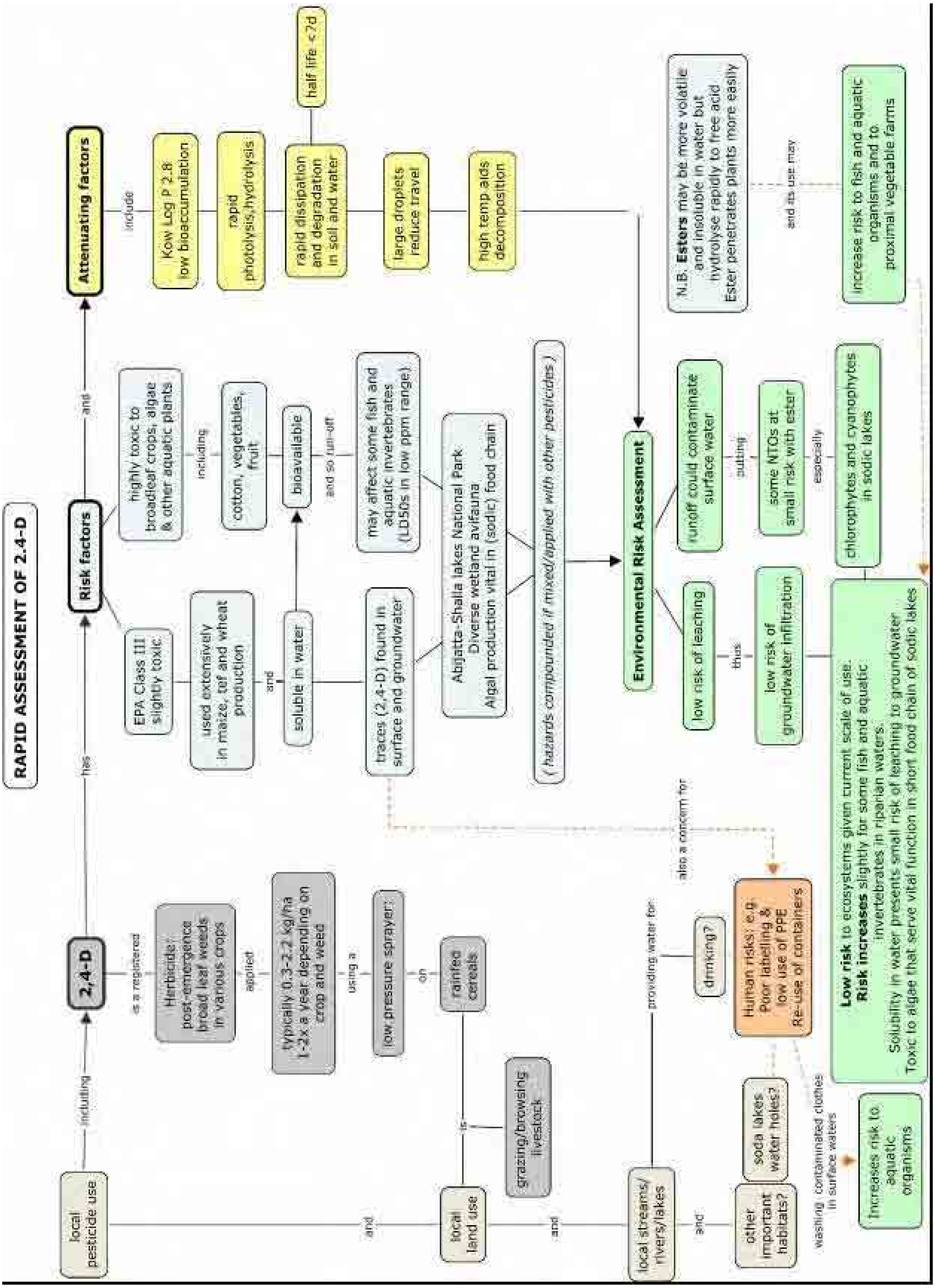
Risk Management: judging from survey returns:
For environmental protection
Provide training/awareness raising on

- the importance of all farmers reading and heeding instructions on pesticide containers/packaging – if they cannot read labels, they should find someone who can, to ensure correct dosing OR refrain from use
- all farmers taking heed of wind direction and other weather conditions which affect fate of pesticides
- dangers from use of old and obsolete pesticides – they should NOT use pesticides without proper containers and without labels
- over-use of herbicides may have a detrimental effect on beneficial insects and invertebrates within their cropping systems and lead to a higher risk of crop losses
- alternatives to pesticides for crop protection and livestock care
- assessment of benefits vs risks from pesticide use (given the fact that positive results from pesticide use was not always recorded by the survey). Is it necessary to spray? Is it economic to do it with such frequency?
- Avoiding unnecessary contamination of soil and water by pesticides
- Importance of reporting environmental incidents potentially resulting from pesticide use to the PIC DNA

For human health
Provide training/awareness raising on

- correct disposal of used/empty pesticde containers (given reported re-use of empty containers as food/water storage in a significant % of cases)
- use of protective clothing when handling and applying pesticides (– signif. % spraying in normal clothes, bare hands and feet etc.) – as a minimum, single layer PPE (i.e. long-sleeved shirt, long pants, shoes plus socks, gloves) should be worn
- the importance of reading and heeding instructions on pesticide labels/packaging and NOT using unlabelled pesticides or those with instructions in a foreign language
- storage conditions for pesticide safety with an emphasis on risks to children (NB. Survey showed most stored in house for security)
- health risks from use of old and obsolete pesticides
- alternatives to pesticides for crop and animal health protection
- assessment of necessity (costs/benefits) of pesticide use. Is it economic to do it with such frequency?
- Prevention of unnecessary contamination of soil and water and associated health risks
- The existence of WHO forms to report health effects to local health centres.health officials and of PIC health incident forms to report accidents occuring from “proper use” to the PIC DNA

Rapid Risk Assessment on 2,4-D use in Ziway and Arsi Negele, Ethiopia



ANNEX 4F
RAPID RISK ASSESSMENT OF DDT USED BY RURAL COMMUNITIES IN THE RIFT VALLEY, ETHIOPIA – Ecotoxicity (& Human health risks)

Colin C.D. Tingle & Ian, F. Grant

Pesticides in general are sometimes anecdotally referred to as “DDT” in African countries and it is possible that this is the reason for the high use of DDT identified by the survey in rural communities in the Rift Valley. However, for the purposes of this risk assessment, it will be assumed that the chemical DDT is being used as indicated by the survey.

This RRA was carried out to assess the risks specific to DDT use by small-holder farmers in rural communities in the Ziway and Arsi Negele regions of the Rift Valley, Ethiopia (where the locally used application rates are unknown), under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

NB. It is vital that the specificity of this RRA to identified use in Ziway/Arsi Negele communities is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

RAPID RISK ASSESSMENT OF PESTICIDES USED BY RURAL COMMUNITIES IN THE RIFT VALLEY, ETHIOPIA – Ecotoxicity (& Human health risks)
DDT

DDT Product/Trade names: Unknown for the Ethiopian Rift Valley – just known as DDT

Insecticide containing ACTIVE INGREDIENT: dichlorodiphenyltrichloroethane (DDT)
FORMULATION: DDT may be available in several different forms in Ethiopia; however the product used for malaria control (the probable source of DDT to smallholder farmers in Rift Valley rural communities (Safe Environment Group, 2003)) is the 75% wettable powder (WP). This is prepared at Adami Tulu formulation plant, not far from Ziway.

Rapid Risk Assessment

In Ethiopia, DDT use is restricted to mosquito control for malaria prevention. Central Rift Valley communities report, however, it's current use in agriculture for crop protection. It is assumed that the formulation used for malaria control (see above) is also that used in agriculture, as no other should be available to farmers.

The pattern of use of DDT on crops in the Rift Valley is unknown. It is, however, recorded in the surveys of Ziway and Arsi Negele as a very major component of pesticide use in the Rift Valley communities sampled (almost 29% of respondents to the questionnaire). Of the insecticides used by the communities, DDT was the most common, followed by malathion (±9%), profenophos and endosulfan (<2% each).

There is no recommended application rate for DDT on crops, as it is not supposed to be used for agriculture in Ethiopia. It is thus impossible to determine likely deposition rates of DDT on soil, on plant material and in water.
For the purposes of this rapid risk assessment, an alternative approach will be taken based on the risks known from given application rates in particular climatic/ecozones.

DDT was used for tsetse fly control in Zimbabwe and sprayed at an overall application rate of 160-250 g a.i./ha. However, such ground-sprayed DDT is applied highly discriminatively and concentrated on specific spray targets within spay swaths approx. 60 m across. Thus deposition amounts to 1 kg/ha or 0.005-1.0 g/m^2. This led to residue levels on sprayed tree bark of 0.5-93 μg $\sum$DDT/cm^2 and between 0.01-200 ppm within the top 5 cm of soil (the higher levels (1-200 ppm) being found only under sprayed trees).

Typical application rates in agriculture in temperate areas was around 1-10 kg/ha per season, resulting in mean levels of 2 ppm in soil (depending on crop – up to 100 ppm could be found in orchards). Trials in Nigeria used 10-20 kg/ha/yr (via multiple applications at 1 kg/ha). There is a possibility that DDT wettable powder may be used direct as a dust in smallholder agriculture – this would result in much higher deposition rates than above. However, this is speculation and will not be used within this risk assessment. If this practice is discovered in Ethiopia, then the risks evaluated here will be considerably increased.

Environmental risks

As a general rule, the acute toxicity of DDT ranges from highly toxic (many arthropods and to some fish) to moderately toxic (many birds, amphibia) to slightly toxic (mammals). However, acute toxicity is not often directly reflected in the field, due to a variety of attenuating factors. The key issues with DDT are its persistence and its tendency to bioconcentrate and bioaccumulate, particularly in adipose tissue – thus chronic exposure is the chief problem. Through this process, DDT can reach toxic quantities within the bodies of animals. Although persistence is reduced in the tropics, the risks below take this into account being based on results in Zimbabwe (unless otherwise stated).

The DDT breakdown product DDE also causes serious problems. It leads to thinning of bird eggshells and can cause breeding failure in birds. Like DDT, it also bioaccumulates. Basically, for DDT, the higher up the food chain, the greater the risk.

The application rates used by the rural communities surveyed in the Rift Valley is not likely to be lower than the overall application rates used in Zimbabwe, indeed it is likely that deposition rates will exceed the higher end of this range.

At these levels, high risk is posed to raptors and to a range of insectivorous birds (perhaps up to 30% of species in the case of the latter). These groups may suffer serious population decline (90% reductions) and certain raptors may even disappear completely from sprayed areas following 3 or more years of DDT application. About 8.5% of woodland songbird species are potentially at risk. It is difficult to estimate those at risk of serious population decline: agricultural use tends to lead to more widespread risk than ground-spraying for tsetse control, but the bird fauna may be limited. The raptors at high risk are bird predators and, if DDT enters the aquatic environment, piscivorous birds (although those favouring reptiles may also suffer).

There is also a moderate to high risk to reptiles, particularly snakes and lizards who's populations risk declining by up to 40% (possibly higher for snakes) in areas treated twice or more.

Frogs and toads are generally less susceptible to DDT than reptiles and will probably be at lower risk, but these animals (along with snakes) were not studied in Zimbabwe thus their reaction under south east African conditions is unknown.

The risk to non-target invertebrates is likely to be low, with predators and parasitoids being those more at risk of population effects amongst the epigeal and vegetation dwelling inverts. Some invertebrates (certain ants e.g. *Camponotus* spp., termites, etc.) although tolerant of DDT can accumulate high residue concentrations (<218 ppm dry weight were recorded in Zimbabwe) and thus provide a route for bioaccumulation through the food chain.

There is a low risk also to soil macroinvertebrates and potentially to soil nutrient cycling.

There may be a low risk to insectivorous bats and possibly other small insectivorous mammals through accumulation of DDT and its metabolites in fatty tissue, which may release acutely toxic quantities at times of stress or where food intake is low.

A key issue for farmers in the rural communities is that there is a moderate-high risk of disruption to the pest/natural enemy balance within cropping systems (depending on the crop and application rates and methods), which could produce pest resurgence and the need to apply ever higher doses of DDT in order to maintain control of target pests, so leading to a pesticide treadmill and increasing pest problems.
Another closely related risk is that of the development of resistance, which further exacerbates the pesticide treadmill risk.

At higher rates of application (it is unlikely that more than 10 kg/ha would be used), the risks of adverse effects spreads to a wider range of invertebrates, including some spiders and a wider range of detritivores. The risk of disruption to predator/parasitoid/prey relationships increases along with the scale of the disruption experienced.

The higher up the food chain, the greater the increased risk and the risk of effects on bat populations may become moderate. A greater range of species of birds of prey will be at high risk. Persistence also increases, as does the risk of the insecticide getting into waterways via runoff (given rainfall).

DDT generally doesn't easily get into aquatic systems through run-off, due to its low water solubility and tendency to bind to organic matter.

However, if poor spray application technique leads to direct spraying of waterways or if poor management leads to farmers washing their application gear in local streams, lakes or other water bodies, then the risks to aquatic fauna are high and serious. DDT binds very quickly to suspended particulates and sediment and so is withdrawn from the aquatic phase very rapidly. That leaves most inverts and fish unaffected, except those that filter water as a feeding strategy or are bottom feeders *e.g*. bivalve molluscs, catfish, etc. These may not suffer immediate mortality, but can accumulate high residues.

Contamination of streams and other water-bodies from run-off from crop spraying is unlikely to be higher than those experienced from tsetse spraying in Zimbabwe and thus risk to populations of fish is probably negligible to very low. Similarly, risk to populations of aquatic invertebrates (even those crustacea that are most sensitive) is likely to be low. However, the risk of accumulation of residue levels through the aquatic food chain is high and the risk to populations of fish-eating birds is likely to be low to moderate. This may lead, in turn, to some eggshell thinning and possibly hatching failure, but from the Zimbabwe experience this alone is unlikely to cause population decline when contamination of waterways is at very low levels. Bioacumulation of DDT residues in shellfish is inevitable, but maximum levels may still be relatively low.

However, levels of contamination of aquatic ecosystems from poor pesticide management practices (e.g. spraying directly adjacent to waterbodies and/or washing spray equipment in waterbodies) may lead to a moderate to high risk, both to aquatic invertebrates, some species of fish and particularly to fish-eating birds (cormorants, terns, pelicans, herons, fishing owls, osprey and other piscivorous raptors).

These practices would also lead to high risk of some disruption of the ecological balance of the aquatic systems.

Due to its persistence in sediment, the risk from DDT to aquatic systems will continue to increase as long as DDT continues to be applied to surrounding fields (particularly if accompanied by poor management leading to direct contamination of waterways), even if actual application rates are relatively low.

DDT is found almost everywhere in the world, even far from any point of use. Despite making a tiny contribution, use of DDT in the Ethiopian Rift Valley will increase global levels of this persistant organic pollutant, as volatilisation in the tropics is high.

Human health risks

Those applying and managing pesticides
Given the levels of poor understanding of pesticides and poor pesticide management uncovered by the survey, it is clear that there is a significant risk to those who use and apply (as a spray) DDT of contamination of skin, eyes, etc. and possibly even ingestion. DDT is of

relatively low toxicity to people and risks of acute toxic effects (nausea, diarrhea, increased liver enzyme activity, irritation (of the eyes, nose or throat), disturbed gait, malaise and excitability) from the use and application of DDT (used at rates assumed above) are low. Risks of tremors and convulsions from higher doses are even lower BUT (given poor pesticide awareness) certainly conceivable.

Chronic toxicity via liver and kidney damage or immune system suppression are also very unlikely unless high levels are ingested. Adverse effects on the liver, kidney and immune system due to DDT exposure have not been demonstrated in humans in any of the studies which have been conducted to date.
Potential risks of reproductive effects, mutagenicity, teratogenicity and carcinogenicity are dealt with below, though they may be at a slightly higher risk rating in this group of pesticide appliers. Certainly chromosome damage has been recorded in men subjected to occupational exposure to DDT over long periods.

Those in the rural community
The key risks of contamination are to children from accidental ingestion of DDT stored within the house; to families through drinking DDT contaminated water (it's insoluble – so they need to drink water containing particulate matter/sediment to ingest it) and to families through eating contaminated fish or other fresh water animals caught locally. DDT does not generally contaminate groundwater and there is very low risk of this happening in the rift valley.

Women exposed to DDT can accumulate residues in breast milk, so leading to exposure of suckling infants.

As above, risks of acute or chronic toxicity from any of these routes of contamination are very low, unless large quantities (>315 mg/kg of DDT 75% WP) are ingested. For children the risk is greater and as little as 2 g of DDT 75% WP may be fatal. Of the above contamination routes, only mistaken ingestion is likely to result in this level of contamination.

There is no proof of effects of DDT on the human reproductive system, but there is evidence in other mammals (sterility, decreased foetal weights, decreased embryo implantation, irregularities in the oestrus cycle and miscarriage). The risk of this in the rural communities studied in the Rift valley is negligible (no reproductive effects due solely to DDT have ever been demonstrated in humans). However, there is evidence (though conflicting) that DDT is mutagenic/genotoxic (causing chromosome aberation or damage), and it also may be teratogenic (causing impaired learning and/or impaired physiological development). Children suckled by women with high breast milk residues of DDT in South Africa (from spraying inside houses for malaria control) have shown impaired reaction times.

There is also disputed evidence over carcinogenicity. It is suspected of having caused increased tumors in lungs and liver in mice. Prolonged exposure is suspected of inducing lukaemia in mice. There is also disputed evidence linking DDT exposure with breast cancer in women. DDT is classified by USEPA as a potential human carcinogen and US Department of Human Health and Security (DHHS) state 'DDT may reasonably be anticipated to be a human carcinogen'. The EPA calculates that ingestion of water contaminated with 10 μg/l everyday over a person's lifetime would increase the chance of developing cancer by less than 1 in 10,000. However, DDT does not remain for long in water, although it does in sediment; thus if villagers drink dirty, contaminated water this level of ingestion is perfectly feasible. Nonetheless, actual likely ingestion rates are impossible to estimate without further study.
The level of DDT residues in breast milk which would lead to the current WHO ADI for infants is estimated to be 5-6 mg/kg/day. This level is commonly found in areas where DDT is in active use (indeed up to 15.8 mg/kg have been demonstrated in South Africa) and thus risk of infants exceeding the WHO ADI in the rift valley rural communities are high.

Although the risk of any of the above more serious health effects is low, the potential for prolonged exposure to DDT does exist within these villages and there is the risk that amongst the population there is someone who may suffer from the above hazards. On the precautionary principle, the need to inform the local people of the health risks of DDT is vital, before anyone suffers some of these health effects.

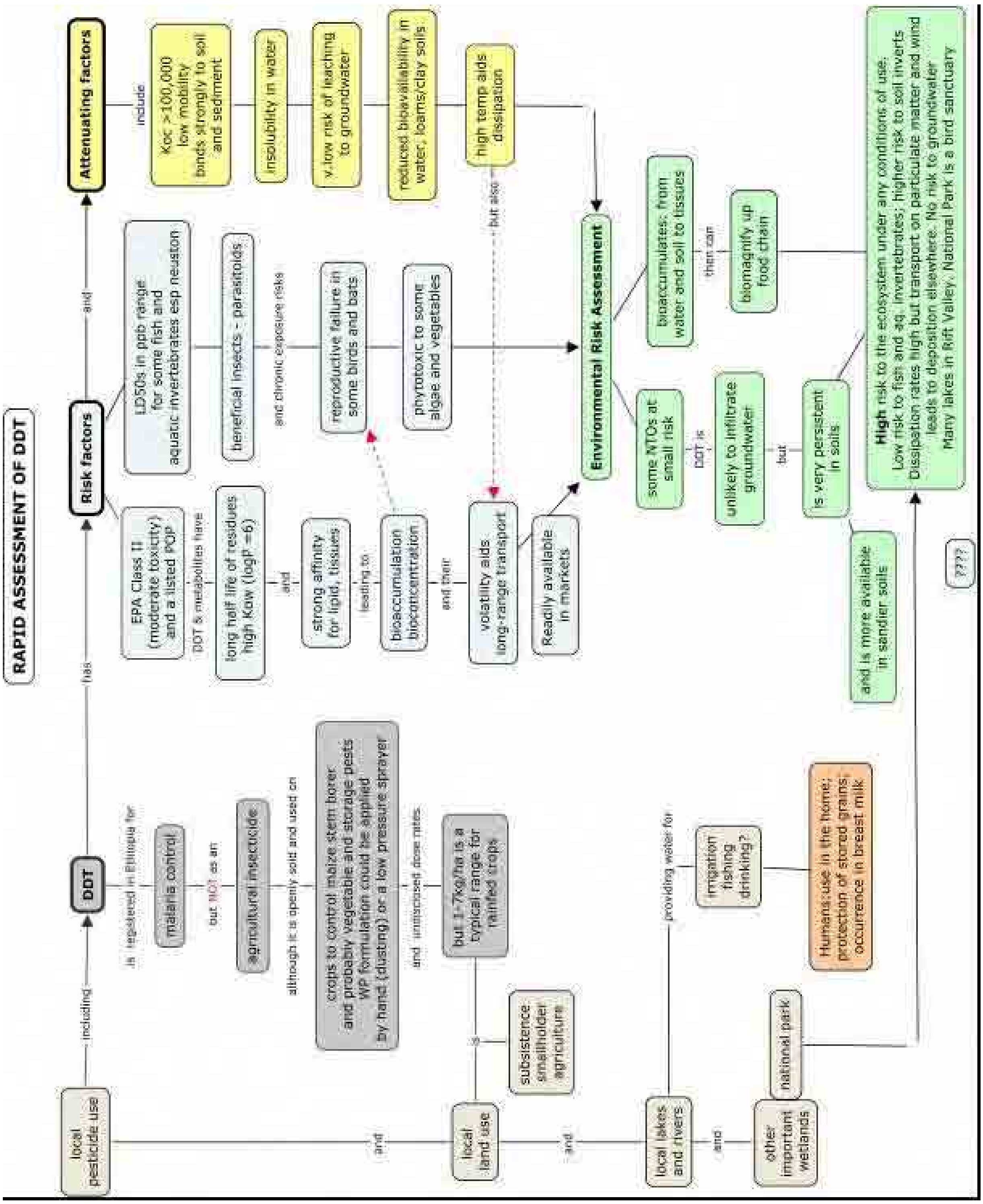
Risk Management: judging from survey returns:
For environmental protection
Provide training/awareness raising on

- dangers from use of DDT (and other old and obsolete pesticides) – it is illegal to use DDT for agriculture and DDT must not be sold or used
- assessment of benefits vs risks from pesticide use given the fact that DDT can cause pest resurgence, the development of resistance and the potential entry onto a pesticide treadmill. Is it necessary to spray? Is it economic to do it with the frequency they do?
- alternatives to DDT (and other pesticides) for crop protection and livestock care
- Avoiding unnecessary contamination of soil and water by other pesticides (given that they won't use DDT)
- Importance of reporting environmental incidents potentially resulting from DDT use to both PIC DNA, POPs focal point and other relevant authorities
- the importance of all farmers avoiding the use of unlabelled pesticides and of reading, heeding instructions on pesticide containers/packaging (where they have them)
- all farmers taking heed of wind direction and other weather conditions which affect fate of other pesticides and ONLY proceeding with application under suitable conditions

For human health
Provide training/awareness raising on

- health risks from use of old and obsolete pesticides, with message not to use DDT
- correct disposal of used/empty pesticide containers (given reported re-use of empty containers as food/water storage in small % of cases)
- use of protective clothing when handling and applying pesticides (– signif. % spraying in normal clothes, bare hands and feet, etc.)
- the importance of reading and heeding instructions on pesticide labels/packaging and NOT using unlabelled pesticides or those with instructions in a foreign language
- storage conditions for pesticide safety with an emphasis on risks to children (NB. Survey showed most stored in house for security)
- alternatives to pesticides for crop and animal health protection
- importance of reporting health incidents (however minor) resulting after contact with DDT or other pesticides to local clinic, PIC DNA and (for DDT) the POPs focal point
- Prevention of unnecessary contamination of soil and water and associated health risks

Rapid Assessment of DDT



ANNEX 4G
RAPID RISK ASSESSMENT OF MALATHION USED BY RURAL COMMUNITIES IN THE RIFT VALLEY, ETHIOPIA – Ecotoxicity (& Human health risks)

Ian, F. Grant

This RRA was carried out to assess the risks specific to the particular formulations of Malathion at the use rates identified by the community survey in the Ziway and Arsi Negele regions of the Rift Valley, Ethiopia and at (where available) the locally used application rates, under the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.). Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative, but with quantitive elements wherever possible.

NB. It is vital that the specificity of this RRA to identified use in Ziway/Arsi Negele communities is recognised – the results are only transferable to other use situations provided relevant adjustments are made.

RAPID RISK ASSESSMENT

ETHIOLATION (MALATHION) $C_{10}H_{19}O_6PS_2$

Ethiolation or malathion is a non-systemic, broad-spectrum, organophosphate insecticide used for the control of agricultural pests. It is registered for use in Ethiopia to manage pests of maize, sweet potato and cereals. Other branded formulations of malathion can also be used in Ethiopia against crop, migratory (locust, African armyworm) and animal pests (ectoparasites). Ten percent of farmers in the areas surveyed use malathion.

Classified by the USEPA as a Class III compound (slightly toxic), its mode of action is neurotoxic, acting as a cholinesterase inhibitor. Malathion is neither listed as teratogenic, carcinogenic or mutagenic, nor is known to have reproductive effects or to cause endocrine disruption (there are however, still some data gaps). It is rapidly and effectively absorbed via practically all routes (contact, ingestion and inhalation) and its mode of action presents some likelihood of risk to non-target vertebrates and arthropods, depending on the mode and degree of exposure. It is not toxic to plants. Malaoxon, an oxidative product of malathion that is produced under certain conditions[7], is more toxic than its parent.

Recommended dose rates (malathion) for agricultural pests vary with crop and pest type: e.g. 1kg ha^{-1} for maize; 3kg ha^{-1} for certain fruits, but in practice, subsistence farmers and smallholders may apply considerably less or more. Two to five applications per growing season are not unusual. Assuming that 50% of applied pesticide misses the target, control of maize stem borer twice in one season can result in 1kg ha^{-1} being deposited on the soil. Wash out from crop foliage may increase the soil burden further, and run off after heavy rain could transport the compound to surface waters. For storage pests such as maize grain borers, pesticide deposition is limited to the immediate vicinity of the storage system.

The persistence of malathion (and malaoxon) in soil and water is short. Hydrolysis and microbial action rapidly degrades malathion in soil (average half life is 2 days – range: 1-25d) and water (<7d). Anaerobic degradation in soil and sediment is slower (average 30d). Its persistence is extended in dry, sandy and acidic soils but shortened with increasing soil moisture, N content and alkalinity. Malathion is not strongly adsorbed and bound to soil, and its solubility in water increases the potential risk of transfer to surface and groundwater supplies (detected in 0.4% of wells tested in the US).

The receiving environment in both survey areas is farmland of the central rift valley floor that lies in the tepid-to-cool sub-moist lakes zone (AEZ: SM2-2) at altitudes between 1600 - 1700m (around Ziway -Akabab) and between 1600-1900m to the south (around Bulbula and Arsi Negele). Smallholders and subsistence farmers rely on rain fed arable crops (maize, tef, wheat, sorghum and vegetables) and grazing (cattle, goats, donkeys). The surrounding vegetation is wooded grassland and open woodland consisting mainly of different Acacia species. Four lakes, Ziway, Abijatta, Shalla and Langano, dominate the valley floor: Ziway is used mainly for fishing but little is fished from Langano or the two sodic lakes. The Abijatta-Shalla lakes National Park (and possible future Ramsar site) is an area of 850 sq miles (35% water) that borders the district if Arsi Negele and is a major habitat for a diverse avifauna, especially wetland birds. Drainage from the surrounding catchments is towards the lakes in the rift valley floor.

[7] malaoxon can occur via oxidation during water treatment processes or through reaction with the ambient air. The oxidation of malathion to malaoxon via ambient air does not readily occur on biologically active material (plant surfaces)

Vertic Andosols is the major soil type in the survey area of the central rift valley, with Vertisols occurring on the slopes to the east of Arsi Negele. The surface soil (Andosols) tends to be porous, friable, and of low base saturation. These soils become sandier towards Arsi Negele and some have very high sodium contents, which precludes agriculture. In the rainfed cropping areas, the pH will likely vary between slight acid to alkaline. Breakdown of malathion will be retarded in drier, sandier areas where the pH is < 7 and accelerated in more alkaline soils and, in the event of run-off, surface waters (e.g. L. Ziway pH 8.6; L. Abyjatta and L. Langano both pH 9.8). The risk of leaching is increased in the more porous, sandier soils.

Exposure of wildlife to malathion will result from crop applications, airborne drift (droplets and dust), contaminated diets and run-off to surface waters. However, smallholder farmers are employing low pressure sprayers (74%) and EC formulations that mostly generate droplets too heavy to drift far in favourable winds[8]. Dusts are susceptible to wind borne drift but their use is highly contained - dusted over stored crops for control of post-harvest pests. The risk of significant run-off to surface water is small in lowland rain fed areas (>70% of farms). Heavy rain on sloping land (16%) significantly increase the chances of run-off, as will furrow irrigation in the areas west of L. Ziway and along the Bulbula river (if employed). Indiscriminate spraying near water (16% of farms adjacent to streams), and poor practices (dilution, mixing and cleaning of equipment near water courses) present significant toxic hazards to aquatic fauna.

Malathion is lethal to many non-target arthropods including beneficial insects such as natural predators and pollinators. It is fortuitous that the dominant crops - maize, tef, wheat and sorghum - being cereals, are wind pollinated. Bees are highly susceptible through direct contact but would not transport cereal pollen to hives/nests. The short persistence of malathion in the environment attenuates its impact on wildlife. [Nonetheless, the surveys suggest that increases in pesticide use could be related to observed decreases in bees, other pollinators, mosquitoes and spiders] Birds, reptiles and small mammals are at v. low risk of poisoning in crop areas as they are efficient at metabolizing and detoxifying malathion. Outside crop areas, terrestrial organisms are at little risk of exposure as the methods of application do not cause pesticide drift. Malathion gains entry to aquatic ecosystems via run-off and (badly managed) riparian spraying. Malathion is soluble in water and does not bind strongly to suspended matter: both factors that increase its bioavailability and toxicity to aquatic fauna. Low ppb concentrations are lethal to some fish, tadpoles, and nearly all aquatic invertebrate groups. Locally valued fish such as *Oreochromis*, *Clarius* and *Barbus* spp. are moderately susceptible (96h LD_{50} in low ppm ranges).

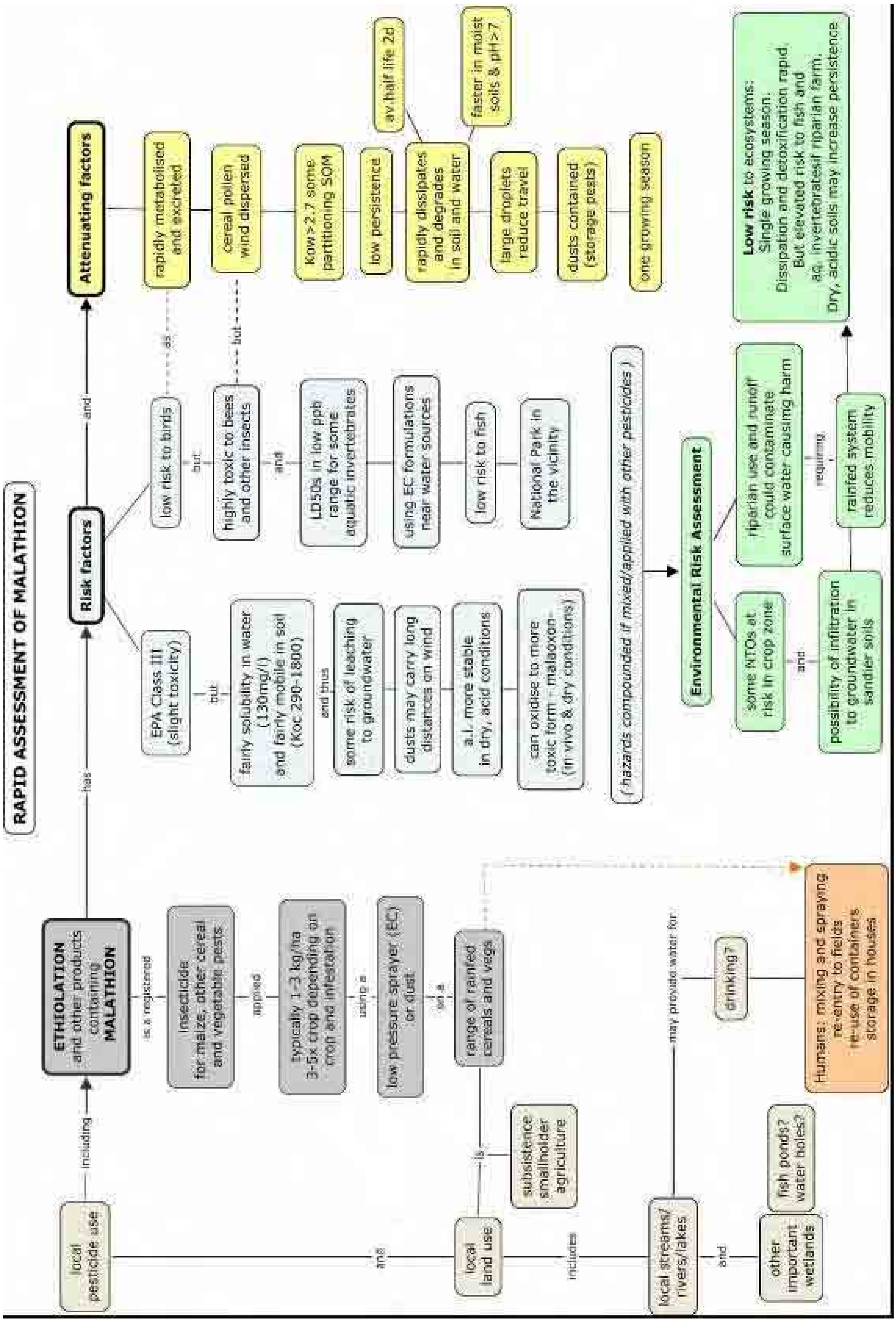
Applying mixtures of malathion and other pesticides may increase the risks to non-target organisms and ecological functions through potentiation of toxicity (synergistic effects of combined use).

In summary:
The impacts of malathion on wildlife in the crop and surrounding environment are limited by
- rapid dissipation and breakdown in soil and water (but slower in acidic, sandy soils)
- dominance of rain-fed cereal crops on lowland plains (rainfall, pollination, gradient)
- dilution factors of, and distances from, rift valley water bodies

There is a small risk that the mobility of malathion facilitates:
- leaching to groundwater and wells: especially through sandier soils after rain
- run off to fishponds and streams that could result in low ppb levels
- acute toxic responses of some soil fauna in dry, sandy soils

[8] i.e. ideal spraying conditions. Very few farmers use spinning discs (2%) and vehicle mounted sprayers (4%) that generate aerosols for drift spraying and no ULV formulations of malathion are registered for use in Ethiopia.

Rapid Assessment of Malathion



ANNEX 4H
RAPID RISK ASSESSMENT OF MALATHION USED BY RURAL COMMUNITIES IN MOPTI REGION, MALI – Ecotoxicity (& Human health risks)

Baba Gadji, Colin C.D. Tingle & Ian, F. Grant

This RRA was carried out to assess the risks specific to Malathion used by the community survey in Mopti region, Mali. However, no information was available on specific formulation(s) used locally, nor on application rates, nor on the conditions specific to the target rural areas (habitats, flora and fauna, soil types, topography, hydrology, etc.), nor on the crops to which malathion is applied in Mopti. Insufficient data was available to allow a truly quantitative risk assessment to be made. The RRA is thus largely qualitative and generalised, but with quantitive elements specific to Mopti wherever possible.

NB. This RRA is best read in conjunction with the RRA on malathion use in Ziway/Arsi Negele communities whilst recognising the elements that make the RRA specific to those Ethiopian Communities – the results are transferable to other use situations (such as that in Mopti) provided relevant adjustments are made.

Evaluation Rapide des Risques (ERR) du Malathion

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1. Groupe de pesticide : Organophosphorés:

1. Produits dits de choc, parce que souvent hautement toxiques, Volatiles, liposolubles et non persistants.
2. Inhibiteurs de cholinestérase
3. large spectre d'action.

2. Formulation: les types de formulations qui peuvent être disponibles sont :
- Concentré émulsifiable
- Poudre
- Liquide ULV

3. Toxicité:

✓ **Toxicité aigue**

Rat
- Oral: DL_{50} 1 375 mg/kg,
- Dermale: DL_{50} 4 400 mg/kg,

Chien
- DL_{50} 1 600 mg/kg, v. Intraveineuse

Cobaye
- DL_{50} 500 mg/kg, v. intraveineuse

✓ **Toxicité chronique:**

Pas d'effets chroniques observés sur l'activité cholinestérasique pour l'homme avec ingestion de faibles doses.

4. Effets Ecologiques:

✓ Risque faible sur vertébrés terrestres.

Malathion est peu toxique pour la majorité des mammifères; modérément toxique pour les oiseaux : DL_{50} 100 (merle) à 1485 (canard) mg/kg. Près de 90% de la dose ingérée par les oiseaux est métabolisée et excrétée en 24 H avec les excréments.
Peu toxique pour des réptiliens (DL_{50} 2324 mg/Kg pour *Anolis carolinensis*).
Risque d'exposition aux quantités qui peuvent produire un effet négatif sur les populations des vertébrés terrèstres est très faible.

✓ Risque modéré à élevé sur les invertébrés terrestres non-cible.

Des réductions de densités d'ennemis naturels ont été observées sur le terrain. Au laboratoire ED_{50} (96 h) varie entre 18 et 33 μg/g par insecte pour *Pimelia senegalensis*.

Mortalité des larves de lepidoptère, des Hemiptères, des Hymenoptères (Cynipoidea) et des aragnées a été observé apres application de malathion et les populations de coccinelles étaient réduit pendant 3 semaines apres traitement. Alors, risque modéré mais temporaire pour les invertébrés non-cible dans les champs individus traités avec des doses dans la gamme reconnu globalement.

Risque élevé pour les abeilles. Ce risque sera réaliser si les cultures traitaient avec malathion sont attirant aux abeilles et le traitement co-incide avec l'activité de fourrage et les doses sont dans la gamme normale dans la monde.

✓ Risque élevé sur les invertébrés aquatiques.

DL_{50} sur *Daphnia* est de CL_{50} 0,0009 mg/l (24-25h) et de 1 μg/L à 1 mg/L pour la plus part des invertébrés aquatiques (insectes, microcrustacés, zooplancton).

La réalisation du risque est probable si malathion est traité sans précision directement à coté d'un ruissau, rivière ou plan d'eau ou si les pulverisateurs ou autres équipement de traitement sont lavés dans ces plans d'eau. Autrement, la risque sera moins (faible à modéré).

✓ Risque élevé sur les vertébrés aquatiques.

Malathion est toxique aux stades de développement en milieu aquatique des amphibiens.

Toxicité variable pour les poissons : 96-hour LC_{50}
Très toxique pour « walleye » (0.06 mg/L)
Toxique pour truite brun (0.1 mg/L)
Faiblement toxique pour poisson rouge (10.7 mg/L).

Des cases de grandes mortalités de poisson après traitement avec malathion ont étés observés. La réalisation du risque est similaire que celle décrit au dessus.

✓ Comportement dans l'environnement.

- Peu persistent dans le sol avec une demie vie de 1 à 25 jours
- Se dégrade rapidement par photo dégradation
- Soluble dans l'eau, avec une possibilité de se retrouver dans les eaux souterraines
- Les résidus sur la végétation sont plus élevés dans les partie du végétal riche en lipide

5. Effets sur la santé humaine:

✓ Risque négligible sur les êtres humaines dans la population génerale, mais faible à sévère pour les pesticide applicateurs/opérateurs.

Etant donner la faiblesse de toxicité de malathion, la risque des effets sur la santé pour la population générale de malathion utilisé dans la protection des végétaux est prêsque négligible.

L'utilisation (identifié par le mini-projet) de malathion pour la conservation du poisson seché par les vendeuses (même que c'est une utilisation ilégale) présent un risque inquantifiable (étant donner qu'il n'y a aucun donné sur les quantités utilisés), mais de concerne pour les consommateurs (voir ci-desous).

Pour ceux qui travail avec malathion les risque sont présent et pour des individus concerné peuvent se mets en rang de failble à élevé. Plusieurs cases d'empoissonement avec malathion ont se présentés parmi des travailleurs.

Les risques sont plus hautes pour les femmes et sutout pour les enfants.

Les risques dépends aussi sur le niveau de nouriture. Des personnes avec un défit de consommation de proteine ont un risque élevé.

Avec des doses élevés, commes pour tous les organophosphorés, malathion peut sur-stimuler la système nerveuse en causant la nausé, ètourdissement et/ou confusion.

Des cases sévéres d'empoisenements avec des doses très élevés peuvent se manifester en convulsions, paralyse réspiratoire et mortalité.

6. Propriétés physico-chimiques :

- Nom chimique: diethyl (dimethoxy thiophosphorylthioyl) thiobutanedioate (CA) Diethyl (dimethoxyphosphinothioylthio) succinate (IUPAC)
- Poids moléculaire**:** 330.36
- Solubilité dans l'eau: 145 mg/L (130 mg/l at 20°C) - assez soluble dans l'eau
- Tension de vapeur : 5.3 mPa at 30°C – peu volatile: faible risk de pollution de l'air
- K_{ow}: logP 2.74 – biodisponibilité modéré ; faible rémenance
- La demi-vie pour la dégradation chimique par hydrolyse (pH = 7,4, à 20°C) est d'environ 11 jours et est fonction du pH (hydrolyse lente pour un pH < 7 et rapide pour un pH > 7)

Sommaire des risque pour les communautés surveillés à Mopti

Aucun risque, car l'indication de l'enquete est que le malathion n'est pas utilisé par ces communautés.

ANNEX 4J
RAPID RISK ASSESSMENT OF ROUND-UP (WITH REFERENCE TO USE BY RURAL COMMUNITIES IN MOPTI, MALI) – Ecotoxicity (& Human health risks)

Colin C.D. Tingle

This RRA was carried out to assess the risks specific to the use of Round-up in the Mopti region, Mali. However, unlike the other RRAs (above) this was not conducted following the guidelines supplied (Grant & Tingle, 2008a & b). Instead, Risk Assessments carried out for Round-up use in the USA were used as the basis for this risk assessment. Insufficient data was available to allow a quantitative risk assessment to be made relevant to the specific conditions and use pattern (etc) in Mopti. The RRA is thus largely quoting directly from the USDA risk assessment and only adjusted to conditions in Mopti where data allow.

(Very, very) Rapid risk assessment (VVRRA) for Round-up (Glyphosate) in relation to use by rural communities in Mopti, Mali, based on limited survey of available reviews and risk assessments

Colin C.D. Tingle

No data is available from the survey carried out in the 5 communes in the Mopti District, Mali, study area in on the use patterns of Roundup (rates of application nor means of application). However, information gleaned during the awareness raising workshop following the survey indicated that although rates of application of 2-4 l/ha were recommended, small scale farmers tended to use 7-8 l/ha, suggesting application rate may be 2-3 x higher than recommended rates.

The following is based almost entirely on risk assessment from the USA.

In relating these results to the Malian situation, it should be remembered that dose rates may be considerably higher than in the USA (although rates considerably lower may also occur due to poor adherence to label instructions); persistence is likely to be significantly reduced (higher volatilisation rates and higher degradation rates); risks to pesticide users are likely to be higher, due to poor understanding of pesticide hazards and lack of protective clothing. *Note:* The assessment below is based largely on glyphosate, but takes account (when stated either specifically by name or when referring to "more toxic formulations") of Polyethoxethyleneamine (POEA) – a toxic surfactant used in formulating Roundup.

For Round-up use in the USA:

Environmental risks

Overview

The current risk assessment for glyphosate draws on the conclusions reached by U.S. EPA: "Based on the current data, it has been determined that effects to birds, mammals, fish and invertebrates are minimal".

Terrestrial ecosystems

At the typical application rate of approx. 2.2 kg/ha, none of the hazard quotients for acute or chronic scenarios reach a level of concern even at the upper ranges of exposure for terrestrial organisms.
For higher application rates 7-8 kg/ha, there is low risk to honey bees (from direct spray), very low risk to large mammals from consumtion of contaminated vegetation and to small birds consuming insects.
Where chronic exposure ocurrs, there is moderate risk to large birds consuming contaminated vegetation. However, the plausibility of this risk being realised is limited because damage to the treated vegetation – i.e., vegetation directly sprayed at the highest application rate – would reduce and perhaps eliminate the possibility of any animal actually consuming this vegetation over a prolonged period.

Aquatic ecosystems

At the typical application rate (2.2 kg/ha), there is negligable risk (although short term effects on amphibian tadpoles may be of greater risk).
At higher application rate (7-8 kg/ha) there is a low-moderate risk for sensitive species of aquatic invertebrates, amphibia (tadpoles) and fish.
This risk characterization strongly suggests that the use of the more toxic formulations near surface water is not prudent.

Exposure risk

The above risk to terrestrial ecosystems is for direct application and thus certain exposure. For relatively tolerant non-target species of plants, there is no indication that glyphosate is likely to result in damage at distances as close as 25 feet from the application site. For sensitive species, there is a modest risk at offsite distances of 100 feet or less. *NB.* These drift estimates are based on low-boom ground sprays. Many applications of glyphosate are conducted by directed foliar applications using backpacks. In such cases, little if any damage due to drift would be anticipated.
Nontarget terrestrial plants are not likely to be affected by runoff of glyphosate under any conditions.
In worst-case scenarios to aquatic ecosystems, the exposure estimates are based on a severe rainfall (about 7 inches over a 24 hour period) in an area where runoff is favoured – a slope toward a stream immediately adjacent to the application site.
Source: USDA

Environmental Fate:

- <u>Breakdown in soil and groundwater</u>: Glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days (range 1-174 days). It is strongly adsorbed to most soils, even those with lower organic and clay content. Thus, even though it is highly soluble in water, field and laboratory studies show it does not leach appreciably, and has low potential for runoff (except as adsorbed to colloidal matter). One estimate indicated that less than 2% of the applied chemical is lost to runoff. Microbes are primarily responsible for the breakdown of the product, and volatilization or photodegradation losses will be negligible.
- <u>Breakdown in water</u>**:** In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms. Its half-life in pond water ranges from 12 days to 10 weeks.
- <u>Breakdown in vegetation</u>**:** Glyphosate may be translocated throughout the plant, including to the roots. It is extensively metabolized by some plants, while remaining intact in others.

Human Health Risks

There is conflicting data on human health risks from Roundup.

Glyphosate is often portrayed as toxicologically benign: "extensive investigations strongly support the conclusion that glyphosate has a very low level of acute toxicity, no evidence of chronic toxicity, organ toxicity, reproductive effects, teratogenic effects, mutagenic effects nor carcinogenic effects....", but others come to a different conclusion, particularly in relation to Roundup. Adverse effects have been identified in each standard category of testing (subchronic, chronic, carcinogenicity, mutagenicity, and reproduction).

It is recommended that the Background data (below) is consulted, but for the purposes of any work in Mopti, Mali, it is suggested that both extremes be presented and a precautionary approach adopted to discussion of risk to health (i.e. recognise worst-case possibilities until science proves otherwise).

Certainly, exposure risks to those applying Roundup in rural communities in Mopti are high and the following minor effects from this should be recognised: Small amounts of Roundup may skin or eye irritation, rapid heartbeat, elevated blood pressure and swelling of the face. Accidental drenching with horticultural Roundup can cause eczema of the hands and arms lasting two months. A spill may result in dizziness, fever, nausea, palpitations, and sore throat. Larger intake may cause: intestinal pain, vomiting, excess fluid in the lungs, pneumonia, clouding of consciousness, lung dysfunction, erosion of the gastrointestinal tract, abnormal electrocardiograms, low blood pressure, kidney damage, damage to the larynx and destruction of red blood cells. Fatality may be caused by ingesting about 200 ml (3/4 of a cup).

POEA (a surfactant in the formulation) is thought to be the major cause of Roundup's toxicity.

It should be stressed that intake of glyphosate should not exceed 0.3 mg/kg body weight/day (**ADI:** 0.3 mg/kg/day). *NB*. The ADI for Roundup may be considerably lower, due to POEA.