

Environmental management in small scale mining in PNG

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Abstract

Although small-scale mining has developed rapidly in Papua New Guinea (PNG), it is only recently that formal recording has been carried to gain insight on employment and production totals, and environmental difficulties. This paper examines the state of small-scale mining in PNG, with special emphasis on its environmental impacts. In recent years, the PNG Department of Mining has become a proactive source of educational activities and information gathering for small-scale mining, its effort directed at devising a comprehensive development plan for the sector. The result has been a tripartite program with active participation from a number of donor agencies and the private sector that promotes integrated rural development and takes into account the important economic and environmental aspects vital for effective poverty alleviation.

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1. Introduction

Small-scale mining is a vital source of rural income generation in many countries around the world. Such is the case in Papua New Guinea (PNG), where small-scale gold mining has become an indispensable part of the rural economy. At the same time, however, this sector of industry has had a wide range of environmental and health-related impacts, and over the past three years, there has been significant effort made to further understand the PNG case. More specifically, attempts have been made to gather a wide range of data related to resident small-scale gold mining activity, with the purpose of using pertinent information to formulate a management plan to administrate and help the small-scale mining community garner the benefits and reduce the risks associated with this form of mining. This paper provides an overview of this process, and outlines some measures for further improving environmental management in the PNG small-scale gold mining industry.

The environmental management challenge in the small-scale gold mining industry can be summarized as follows. On the one hand, although the use of simple

tools such as gold pans and sluice boxes does not cause significant environmental damage individually, when people are agglomerated within small areas, the potential for major problems is multiplied enormously. On the other hand, if small-scale miners opt to use equipment such as water cannons and dredges (both floating and on the land), gold recovery is improved but at the same time, environmental degradation is accelerated.

2. An overview of the PNG situation

Small-scale gold mining in PNG has been carried out since the late 1800s. Since independence in the mid-1970s, an increasing number of people have become involved in the occupation within the rural regions of the country (Figs. 1 and 2). Although the industry has long been ignored by many of the country's rural development programs, the Government has recently recognized its economic importance, and has since made its development and management an integral part of national policy.

A number of donor agencies and the private sector have begun the process of awareness raising amongst communities and supporting the innovative Outreach Program commenced by the Department of Mining. AusAID was the first agency to provide technical assist-

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Fig. 1. Typical small-scale mining activity in PNG; location—Bulolo River, 2nd Bridge, Morobe Province.



Fig. 2. Woman panning in Koranga Creek, Morobe Province.

ance and commit personnel to address a number of issues in PNG small-scale mining communities. Its initiatives aim to enhance environmental awareness, and in some cases, attempt to measure what effects both current and past mining activities may have on present communities.

The use of mercury and creation of awareness of the possible dangers associated with its use is one of the major concerns. In many other Third World countries, mercury has become a major environmental problem in small-scale gold mining regions. Various authors [1–4] have proven that mercury poisoning threatens a number of gold mining communities worldwide. Similarly, in PNG, a number of mercury studies have been carried out, although not on a widespread basis. A number of authors [5–8] have investigated mercury, but have used only a small number of samples, most of which were collected from the Wau/Bulolo area in Morobe Province.

In PNG, there are both large-scale gold mines such as Ok Tedi, Porgera and Lihir, and a flourishing small-scale gold mining industry; there are no medium sized mines per se. Since Independence, emphasis has been on promoting growth within the large-scale mining sector. More recently, however, new policies [9] have been introduced by the Department of Mining to both further clarify the role and importance of small-scale mining, and promote improved financial and environmental management in small-scale mining communities.

In 1998, when The AusAID program began in PNG, it was estimated that between 18,000 and 20,000 people were engaged in small-scale gold mining in the country. By the end of 2001 this estimate changed to 50,000–60,000, with indications of a possible upper limit of 80–100,000 people. These calculations are based upon the results of an informal survey carried out by the Department of Mining over that period of time, which has also proven that every province in PNG has alluvial gold deposits and active miners. These figures are presented in Table 1 and serve as updated statistics to those presented by Tongo and Crispin [10–11]. It is important to clarify, however, that the survey is incomplete, as all mining areas could not be visited due to remoteness and rugged terrain.

Even though this is acknowledged as a conservative estimate, it nonetheless represents 1.25% of the population of PNG. Of these approximately 60,000 people some 20% are women, and an estimated 30% are school age children under the age of 16 [11]. Informal surveys carried out by the Department of Mining over the past three years indicates that approximately 85–90% of all PNG small-scale gold miners use gold panning techniques or sluice boxes without any mechanical aids. Approximately 10% use semi-mechanised equipment and less than 1% use fully mechanised washing plants and bulldozers.

As is explained by Susapu and Crispin [11], the “small-scale mining sector already has considerable

Table 1
Estimated mining population in PNG

Province	Estimated Mining Populations
Bougainville	900–1000
Central	2–300
East New Britain	50–100
East Sepik	10–12,000
Eastern Highlands	1000
Enga	4–5000
Gulf	3,4000
Madang	2–3000
Manus	20–50
Mine Bay	1000
Morobe	15–20,000
National Capital District	Uncertain
New Ireland	4–500
Oro	4–500
Southern Highlands	2–300
Simbu	Uncertain
West New Britain	A few only
West Sepik	3–5000
Western	50–100
Western Highlands	50–100
Total	42,700–53,950

economic impact in PNG”, with “average earnings estimated at approximately K250 per month” (In PNG the currency is the Kina which is valued at approximately AUD \$0.50). The Asian Development Bank (ADB) report on Micro-finance in PNG (2001) indicated that in more than two thirds of the provinces, the average monthly income is clustered around K461 per year and the monetary income is decreasing compared to non monetary income. The income from gold production is based on informal observations of Department of Mining officers, and ranges up to about K550/month. No one knows exactly what these figures are, as it is almost impossible to gather hard data in the remote rural areas of PNG. The ADB figures are based on the National Accounts and published figures with informal observations in the field.

Current gold production in the sector is estimated to be 60,000 oz/yr (MRO production figures)—a value of K60–70. It has been estimated that if illegal exports of gold are included, this value could amount to at least twice this value. Figures quoted for mercury imports are unreliable estimators for gold production for several reasons. The first relates to the inconsistency with mercury consumption. Evidence from other countries indicates that at least four grams of mercury are used to recover one gram of gold and in some places, it is even higher still. Second, there are a number of people who do not use mercury, thus decreasing its credibility as an indicator of gold production. In PNG, some miners are still recovering nugget gold or flakes (40% according to Department of Mining informal reports), and because an

accurate census of small-scale miners is unavailable, the number of people engaged in this activity is undeterminable. Finally, sales and exports are largely uncalculated. It is well documented that many people from the Sepik areas sell their gold over the border in Indonesia. They do this because the price paid is the full gold price, and not discounted because of remoteness from the PNG capital, Port Moresby. Informal information suggests that gold is also exported by ship, along with other cargoes from many different ports in and around PNG.

The next section of the paper examines the environmental impacts of small-scale gold mining in PNG.

3. Discussion: environmental impacts of small-scale mining in PNG

Environmental problems resulting from small-scale gold mining in PNG can be categorized as follows: mercury pollution and physical degradation of the environment [12]. This section of the paper examines each of these impacts in detail. Following this discussion, recommendations for improvement are identified.

3.1. Environmental impacts of mercury from PNG small-scale gold mining activities

To reiterate, mercury is a major health threat throughout the gold lifecycle. Some 60% of the PNG small-scale gold miners surveyed by the Department of Mining are using mercury. According to wholesale records obtained again by the Department of Mining in 1999, excluding additional inputs through illegal channels, approximately four tonnes of mercury is used each year by small-scale miners in PNG (Wholesalers records canvassed by Department of Mining 1999). Most of the gold deposits being worked by PNG small-scale miners are alluvial, requiring gold particles to be separated from waste using simple mining equipment and techniques. In most cases, miners use mercury either in sluice boxes or in a gold pan to separate gold from the black sand.

The mercury/gold amalgam that is produced is then heated to separate the mercury from the purer gold residue. This commonly takes place over the family cooking stove or inside huts. Moreover, because miners typically handle mercury without gloves, they run the risk of it being adsorbed through the skin, and also expose themselves to toxic vapours during roasting (Fig. 3). A more serious threat comes from the continual cooking of amalgam in huts over a period of years, which can also lead to a build up of mercury vapours indoors. This cannot be proven at this stage but occurrences of headaches and nausea—symptoms of mercury poisoning—are obvious indications.

The following is a selected list of observations—all



Fig. 3. Gold amalgam roasting near Watut River, Morobe Province, PNG.

related to the use of mercury—contained in Department of Mining Outreach Program records:

- In the first visit to the Middle Sepik area in November 1999, Bisario, which is near the headwaters of the Crossamarie River, was studied. Here, residents indicated that they were provided mercury by gold buyers to capture fine gold but were not informed of its health implications. As the mercury was supplied free of charge, the intention was for the refined gold to be returned to these buyers. The Outreach Program, through its workshops, helped to educate resident miners about the dangers and risks of mercury to both children and pregnant women. Many people expressed their concern and anger at the lack of information and deception of their mercury suppliers.
- As noted earlier, one common practice in PNG small-scale gold mining communities is the burning of the amalgam cake in huts. The main reason for this is to make sure that raskols (criminals) cannot ascertain the quantity of gold being produced. In a number of communities, the health-related dangers of indoor amalgamation practice have been explained (accumulation of mercury and mercury vapours in huts), and some people have since changed their practice.
- On several occasions, people have been observed to be burning amalgam outdoors but sitting downwind from the smoke. These people have been informed about this danger, and many have since changed their smelting “position”.
- In the village of Sambio in Morobe Province, several people were observed to be burning amalgam cakes on the blades of the same knives used for food preparation. After a visit from the Outreach team, where the dangers of this practice were explained, people

indicated that they would use different methods to burn the amalgam.

To give an indication of how persistent mercury has proven to be in the PNG environment, in the Wau/Bulolo area, where dredge mining began in the late 1920s and continued to the 1960s, it is still common for bulldozers to uncover large puddles of mercury. Similar findings were reported by Metals Refining Operations (MRO), a PNG gold refiner, during a recent field trip to Bougainville (October 2001), where it was observed that the area contained mercury remains from mining carried out earlier this century. Moreover, it is quite common for contemporary hydraulic sluice operators occasionally to dislodge naturally formed lumps of mercury and gold.

Mercury is insoluble and thus persists within river sediments, where it is then transported throughout the food chain, eventually reaching humans. It is often difficult to detect, as it is not unusual for river water to be virtually mercury-free, flowing atop mercury contaminated riverbed sediments [13]. Moreover, anthropogenic inputs of mercury from small-scale gold mining activities add to already-existing natural mercury sinks. For example, recent studies have indicated that significant inputs of mercury in the environment originate from the burning of native forests. In the Amazon basin it has been argued that up to 50% of the mercury present in the waterways and subsequent mercury poisoning in people comes from this source [1,3]. This is important in the context of PNG because of the drought in 1997–8, when huge tracts of forest were set ablaze in and around the Wau/Bulolo mining area.

As already indicated, several small studies have been carried out over the years to determine mercury levels in humans and the environment in PNG, some of which

have revealed very high values. The most significant study planned to date is being carried out in 2001–2 in the Wau/Bulolo area, and is being funded by AusAID in the Wau/Bulolo area. Results of this study should be available in early 2002.

The Outreach Program emphasises the dangers of mercury but also provides several ways to try and reduce the dangers of inhaling mercury vapours when “cooking”. Not only are people being encouraged to burn the amalgam outside and keep away from the smoke that is generated, but are also being encouraged to try and recycle the mercury by capturing the vapour and condensing it for reuse. The following two methods are being promoted for mercury recycling:

1. “Tin fish tin”. PNG people enjoy eating tinned fish of various kinds and the tins come in several sizes. They are found all throughout PNG and are a principal waste product. A small tin (with the top removed) is placed in a metal panning dish, after which the amalgam cake is placed inside. A second tin of a larger size is then placed upside down atop of first tin. The dish is then filled with damp ashes or sand, and later placed over a fire, where it is heated for a short period of time. When burning is completed the tins are removed and the mercury trapped in the damp sand is panned out and can be reused (Fig. 4)
2. The second method is simply a small retort made from cast iron pipe fittings and a copper condensing tube. This can easily be transported and used many times.

3.2. Survey of mercury awareness and techniques

As part of the AusAID program in 2001, an evaluation of the effectiveness of the mercury awareness program was undertaken to provide systematic feedback about the Outreach Program. Although informal discussions have revealed important realities and facts, it was determined that a standardised survey would enable data collection to be quantified and presented in a more organised fashion. A survey instrument was therefore developed that covered only knowledge and mercury usage tech-

niques. A pilot survey was carried out to test the validity of the survey and some adjustments were later made in light of results.

The evaluation was initially carried out in the Wau/Bulolo area, although the survey will be conducted in other major mining areas at a later date. People from three villages that had been visited by the Outreach Program over the past two years were interviewed. A control village was used from outside the mining province but still within the general area to compare the basic mercury knowledge of the communities. Questions were mainly asked in Tok Pisin but some individuals preferred to be interviewed in English.

Some of the important findings include the following:

1. Question 17 “Do you cook mercury in your hut?”- Some 80% (20/25) of people interviewed in the visited villages indicated that amalgam cooking did not occur indoors, compared to only 35% (7/20) of the people interviewed in the unvisited villages. It appears, therefore, that the awareness program may have made a difference by persuading people not to cook the amalgam in their living areas.
2. Question 19 “Do you recycle mercury?”-The results obtained from the visited villages 25% (6/24) were identical to the unvisited villages 25% (5/20). No change occurred in spite of the educational program.

Those who did recycle mercury reported using the “tin fish tin” method; retorts are not used because they cost in the range of K100, which proves to be a major obstacle amongst budget-conscious miners. Only those with higher cash flows should therefore be targeted as far as promoting increased retorting is concerned. Follow-up informal discussions revealed two additional reasons for the lack of retort use. The first relates to the fact that the gold sponge is burnt within a closed atmosphere in the retort. The sponge can change colour and needs to be cleaned afterwards to reveal the true colour. This is significant because gold is bought on the basis of colour and density: the more silver contamination, the less golden the colour, hence, the less money received. Around Wau, the price can be as little as K8/gm for 50% product that is silver, and as high as K18/gm for 90% pure gold. The second reason is that there is a misconception amongst people that mercury can be used only once; “pure” mercury is bright silver colour and when used becomes less shiny. Once dulled, people often discard the used mercury with concerns that it is less effective.

Although not recorded in the survey response sheets, discussions afterwards with people in visited villages revealed that certain miners had made certain key decisions about their mercury practices. More specifically, they indicated having changed mercury management practices, highly concerned about its toxicity and

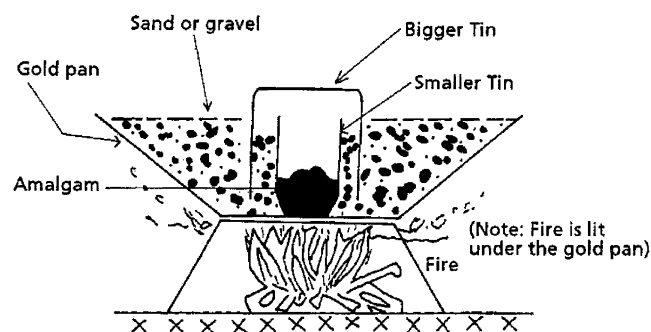


Fig. 4. “Tin fish tin” method for mercury recycling

health-related impact on both children and pregnant women. Two examples given in several cases was ensuring that people are kept away from the smoke released from the burning of amalgam, and the predetermining of wind direction before lighting a fire. Indications of such improvement were further reinforced during a visit to Kobiac Village (unvisited village) on 7/11/01, where the headman spoke to the villagers and the Outreach team. He indicated that he had spoken to the people from Miss Booth (a visited village), and they had changed their mercury management practices significantly in response to feedback received.

As far as mercury recycling and reuse is concerned, however, there is still a lack of awareness, which, in all likelihood, is a result of the limited communication skills of the team or the education levels of miners. In fact, the limited education of miners (particularly the older generation) may be inhibiting their understanding of environmental issues. These challenges are compounded by the obvious financial constraint related to the purchasing of retorts, which, as already noted, is beyond the budgetary means of most small-scale miners in PNG.

The survey instrument appears to have succeeded in identifying some of the differences between the visited and unvisited villages, although further refining of the questionnaire may result in more detailed feedback as the Outreach Program continues. For example, there were difficulties encountered when respondents responded “no” to the question “do you use mercury?” as there was no follow-up question to determine miners’ general knowledge of the metal. Asking questions related to the application and impact of mercury would produce more specific and useful information.

3.3. *General environmental degradation*

In addition to causing widespread mercury pollution, PNG small-scale alluvial mining operations located alongside rivers, creeks and banks cause substantial land and aquatic damages. In the Wau/Bulolo area, for example, many artisanal operations are working the tailings from old mines in an already-degraded environment. In areas containing placer gold deposits, such as Mt Kare, artisanal miners commonly dig pits of various depths, all of which are relatively small and shallow. These commonly fill with water and serve as breeding grounds for malaria-infected mosquitoes.

In places where intensive mining activity has occurred for many years, such as Eddie Creek and the Namie area in Wau, landscapes are completely potholed and covered in waste, although some rehabilitation attempts have been made by certain mining companies. Moreover, the practice of digging around the roots of large trees along riverbanks where gold has accumulated will eventually lead to their collapse into the river. This in turn can accelerate erosional processes. As PNG miners have no

mine training, they commonly dig and burrow into the side of mountains with little regard for slope stability and other safety concerns. As a result, several deaths occur each year as a consequence of mudslides and collapsing banks or tunnels.

The Outreach Program run by the Small Scale Mining Branch of the Department of Mining has evolved as a means to try and address some of these issues, primarily through distribution of videos and booklets in both Tok Pisin and English.

The initial three videos were produced using the local mining communities in and around the Wau/Bulolo area, whilst the second series of four were produced using many communities, effectively illustrating how wide-ranging the mining communities are in PNG. The booklets produced, which mirror the subjects of the videos, include:

- Mercury use in Small Scale Mining
- Environment and Rehabilitation
- Occupational Health and Safety

Additional booklets have been published that cover mining techniques, simple economics and gold refining, and manufacturing uses of gold. The support material on the subject of legal requirements for mining will be produced in 2002.

A solar powered TV and video recorder were developed to make presentations portable to all parts of PNG (Fig. 5). This was further developed into a simple solar powered VCD player, thus reducing the weight of the equipment from about 200 kg to less than 30 kgs.

The Program centres around the officers making a presentation to each village or community they visit. Key people are introduced, a brief overview is provided, and a discussion commences. Several videos are then shown depending on the needs of each community. Presentations can last for several hours or well into the night at more remote sites. In PNG, storytelling is a vital part of rural community life and most information is transferred through personal communication.

In many places, although information is available in both Tok Pisin and English, Tokples is used. Translation has to be carried out by local people. The message can then be relayed direct to specific people, and questions can be asked and answered in the local village. There are over 700 different language groups in PNG, and nearly all mining takes place in rural and remote areas, thus making local language a vital component of any communications package.

Over the past three years, Outreach Program officers have traveled by foot, car, canoe, diesel-powered boat, planes of various sizes, and helicopters. This has enabled travel to most places, although there are many villages that must still be visited.



Fig. 5. Outreach Program using the solar powered VCD system, at Maus Bokis, Morobe Province.

4. Recommendations for improvement

The needs of miners in PNG communities extend well beyond mining-related assistance. PNG small-scale mining communities are in dire need of a wide-range of services, including, health, financial, transportation and infrastructure. These needs exist in almost all of PNG's provinces.

Apart from adopting strategies for improving the above-mentioned areas, one means of improving the efficiency of PNG small-scale mining operations is encouraging expanded input from larger mines. Although there has been mixed opinion concerning the integration of small- and large-scale miners in PNG, the case of Misima Mines, which, during their mine closure activities, have formally agreed to include small-scale mining, is an encouraging sign for increased cooperation. On Misima Island, a gold mine has been operating since 1989, and is now entering the closure stage. Its mine closure plan emphasizes providing assistance to the community to cope with the changed economic conditions once the mine is shut. Although mine managers have mainly encouraged agriculture as alternative employment for residents, the financial returns on such activity are restricted because of the island's isolated location, distance from markets, and limited agricultural land. Small-scale mining however, has the potential to replace a major part of the royalties paid out each year (K1.7 million/year), and incomes could quite easily be distributed throughout the community of Milne Bay, and not only to the traditional landowners where the mine is located.

Talks were held with the business development arm of the Misima Mines on these issues. The suggestion was put forward that Misima Mines would consider the possibility of providing a scholarship for one member of the Milne Bay Provincial Administration to work with

the SSM Branch of the Department of Mining in Wau for a period of six months. This in turn would provide some "hands on" experience in all aspects of the industry, with the individual then acting as the liaison for SSM in the Province. This move would be key considering that PNG lacks trained personnel for handling the administration tasks of SSM.

Pollution of fishing grounds from high sediment loads deposited by mining activities may be affecting reef systems and therefore depleting valuable aquatic populations. These problems could be overcome by implementing simple, appropriate technology such as settling ponds. This would be appropriate especially where soils are clay-based, which could lead to sediments being held in suspension for longer periods of time or carried for greater distances.

Support for the mining community to upgrade equipment to improve gold recovery is an important part economic development and environmental protection. This does not require a major upgrade in heavy machinery, but rather improvements to be made to basic equipment. For example, the use of a well-designed sluice box could increase gold recovery and not necessarily require the removal of great volumes of gravel. Most of the people using sluice boxes have "home made" models that are not very efficient. They use only one or no riffles and usually don't contain a mat, which is effective in capturing fine gold. The boxes designed specifically to improve the gold retention cost between K300 and K500, a considerable amount to pay for subsistence operators. Nevertheless, improved sluice boxes can improve gold recovery by a factor of 2–4. Thus, if a loan can be obtained, it could be repaid over a short time period, given the increased gold output resulting from its use.

In PNG, generally, micro finance has proven highly unsuccessful, largely because of the abundance and variability of strategies. This is one of the reasons why

the ADB is setting up a pilot program in Wau. At the moment, there are no banks in Wau, although the region's small-scale gold miners produce between K12–15 million a year, which quintessentially supports the community.

In short, miners operate a cash based economy, whereas many parts of PNG feature a produce-based economy. Gold is available seven days a week to be bought and sold. People are used to handling cheques and cash. Each gold miner is a small businessman, and some employ 2–10 people to help them recover more gold. The aforementioned pilot program will be looking at supporting these small business people and only those who can prove in some way that they are successfully operating will be given access to loans. The aim will be to initially support established small business and not fund 'startups', as the risk is far greater with an unknown system. This means that it will not be targeting the poorest of the poor but rather those who will drive the rural economy and make a success of a family based business.

Whilst the mining community and the money it generates is one of the prime movers for the placement of the pilot project, anyone in the community operating a small business will be eligible for the loans. All profits will remain within the community and be used to help to develop the community bank.

5. Conclusion: a look into the future

Small-scale mining activity is an important economic activity in rural PNG. However, governmental support in terms of funds and manpower resources has been limited and inconsistent over the past decade. The present AusAID funded technical and education assistance program is the first major attempt at providing comprehensive assistance to resident operators.

The experiences and encouragement that can be drawn from the AusAID experience is that despite its financial constraints, small-scale mining functions can be developed and promoted by soliciting resources from within PNG and through external donor sources. The support for small-scale mining in PNG is a tripartite program with Government bodies (including Provincial Administrations), donor agencies and the private sector working together to achieve a number of goals. Perceptions of these goals vary amongst the various stakeholder groups but all have nonetheless recognised that the strengthening of basic economic infrastructure in PNG is an important first step. Contributions from the budget restricted Government and individual private companies are insufficient to improve conditions in the industry. External donor funds will therefore be sought over the next five years.

The proposal by the ADB to commence a pilot micro

finance scheme in Wau, Morobe Province will prove to be an encouraging incentive for small-scale miners. The ADB will provide financial support to the small-scale mining community, particularly to those who demonstrate sound business sense. Possible support from both the Japanese Social Development Fund and the European Union's SYSIM scheme would help to further improve infrastructure, training facilities and pilot programs. The Department of Mining's vision and long-term goals have been documented in a Draft Five-Year Development Plan (D5YDP) for the 2002–2006 Period. The expansion programs proposed for funding under ADB, JSDF and the EU SYSIM Fund would be guided by the priorities set up in the 5YDP document.

Mining activity, both large- and small-scale, has the ability significantly to change the physical landscape. It is therefore crucial to increase awareness of environmental issues, particularly mercury-related pollution problems, the impact aspects of stream diversion, and damage to soil and vegetation. In PNG, this can be accomplished through continuation of the Outreach Program, in combination with demonstration projects. The evaluation of the Outreach Program has shown that it is effective at some levels but will need to continue to evolve and have newly-defined targets. This evaluation should be ongoing to make sure that the message is being continuously assimilated.

In PNG, assistance from donor agencies has been coordinated to ensure that it is targeted and has a direct effect on capacity building within the Department of Mining. The outcomes are targeted toward achieving an improved Small Scale Mining Branch, with professional staff working towards improving the working lives of the rural based communities. Increased attention toward skills, training, environmental sustainability, occupational health and safety issues (including safe use of mercury), and financial services support which undoubtedly facilitate environmental improvements and help to alleviate poverty in many of PNG's rural small-scale gold mining regions.

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