モーリシャス国

公共インフラ・陸上交通省　地すべり対策ユニット

モーリシャス国斜面災害対策支援

業務完了報告書

2018年2月

独立行政法人

国際協力機構（JICA）

国際航業株式会社

環境
JR
18-023

目次

第１章　業務概要

１．１　　業務の背景及び経緯

モーリシャス国斜面災害対策支援（以下、本業務）の背景は図 1 に示すとおりである。

このような世界的潮流を背景として独立行政法人国際協力機構（JICA: Japan International Cooperation Agency）は SIDS（Small Island Developing States）に対する環境・気候変動対策・防災プログラムの一環という位置付けを基本としてモーリシャス国に対し「モーリシャス国地すべり対策プロジェクト」（以下、既往案件）を 2012 年 4 月より 2015 年 7 月にかけて実施した。本業務はこの後継案件として実施されるものである。そのためプロジェクト実施上、気候変動対策や環境、防災対策としてどのような位置付けがなされているかという視点を意識しながら進めることによって、モーリシャスでの貴機構環境・気候変動対策、防災コンポーネント間の相乗効果の発現を目指すものでなければならない。またモーリシャスで実施中の他ドナーによる各種プロジェクトとの協調、情報共有、調整を行いつつ、モーリシャスの政策面、行政面のキャパシティに見合った効率的な技術移転がなされることが重要である。

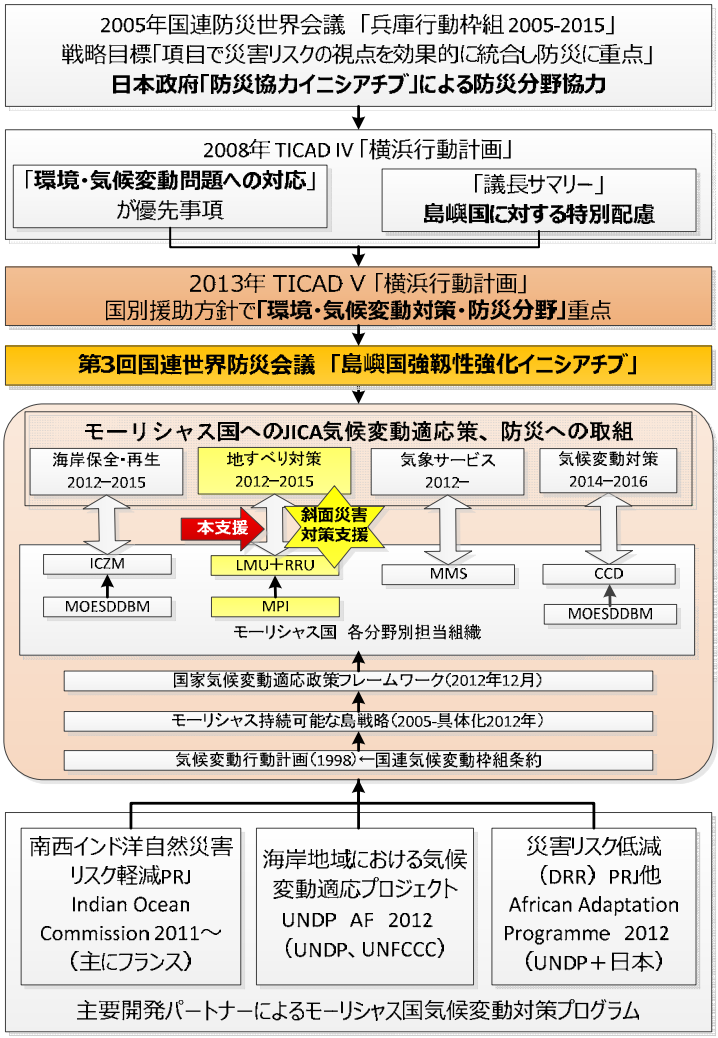


図１：本業務の背景

１．２　　業務の概要

業務概要は表１のとおりである。

表１：本業務の概要

項 目	内容
案件名	モーリシャス国斜面災害対策支援（Landslide Advisor）
対象国	モーリシャス
業務期間	2016 年 1 月下旬 ～ 2018 年 1 月上旬　（約 25 か月）
目 的	モーリシャスにおける斜面災害（地すべり、斜面崩壊、落石、土石流等）への対応能力が強化・向上する。
期待される成果	1. 我が国が 2012 年４月～2015 年７月に実施した既往の地すべり対策案件で技術移転した地すべり対策工や同対策工維持管理が引き続き実施され、技術の定着が図られる。 2. 斜面崩壊、落石、土石流などの斜面災害対策の「調査・解析・設計・施工監理・維持管理」に係る技術が移転される
活動内容	1. 地すべり対策の「維持管理」及び「事業評価」にかかる技術支援 2. 斜面崩壊対策の「調査・解析・設計・施工監理・維持管理・事業評価」に係る技術支援 3. 落石対策の「調査・解析・設計・施工監理・維持管理・事業評価」に係る技術支援 4. 土石流対策の「調査・解析・設計・施工監理・維持管理・事業評価」に係る技術支援 5. 斜面災害に係る遠隔モニタリング体制構築に係る技術支援 6. 斜面崩壊、落石、土石流対策を踏まえた早期警報システム・避難手順の更新支援 7. 斜面崩壊、落石、土石流対策を踏まえた斜面災害防止区域（開発計画政策指針（PPG）の土地利用規制）の更新支援 8. 実施機関の組織強化の継続支援（既往案件提案内容の実施・定着状況の確認及び実施に係る追加技術支援
カウンターパート機関（以下 C/P）	公共インフラ・陸上交通省 /地すべり対策ユニット(Landslide Management Unit: LMU, Ministry of Public Infrastructure and Land Transport: MPI)

第２章　業務実績

２．１　　成　果

本プロジェクトにおける主要成果を下表にとりまとめた。

表 2　成果毎のアクションと成果の概況（詳細実施内容はマニュアル・FR 参照）

支援内容	アクション	成果
地すべり対策の「維持管理」及び「事業評価」に係る技術支援	パイロット事業(Chitrakoot)の現状確認	現状確認実施
	実施済対策工の効果確認および維持管理・事業評価	事業評価実施完了
	MPI 事業計画の進捗（実施状況、現状）確認	第２期工事 2018 年１月末完了予定
	課題・教訓の抽出	FINAL REPORT（FR）に記載
	地すべり対策マニュアルの改訂支援	マニュアル改訂完成、配布
斜面崩壊・落石・土石流対策の「調査・解析・設計・施工・維持管理・事業評価」に係る技術支援	斜面崩壊・落石・土石流の発生メカニズムにかかる講義	日本の教訓を踏まえ、現地調査時やセミナーにて随時実施
	危険区域の特定、実施済み対策工の効果確認（事業評価）	特定された危険地域の調査、設計を行った。
	斜面崩壊・落石・土石流対策の課題・教訓の抽出	FR 及びマニュアルに記載
	調査解析～設計～施工～維持管理までの一連作業の技術移転	マニュアルを用いた現地調査、座学セミナー、OJT により実施
	斜面崩壊・落石・土石流対策の技術ガイドライン及びマニュアルの策定支援	マニュアル完成、配布
	MPI による情報提供のための資料作成支援	MPI 広報セクションと協働
斜面災害に係る遠隔モニタリング体制構築に係る技術支援	現状のモニタリング体制の確認	確認、作動検証・修理済み
	課題・教訓の抽出	課題、教訓抽出（FR）
	モニタリング体制改善に向けた提言	FR に記載
	システムの検討と提案	FR に記載
斜面崩壊、落石、土石流対策を踏まえた早期警報システム・避難手順の更新支援	既存早期警戒システム（Chitrakoot/Vallee Pitot）の状況確認	現地調査を踏まえたシステム提案、EWS マニュアル、AWS を策定
	課題・教訓の抽出	課題・教訓確認（FR）
	早期警報体制改善に向けた提言	FR に記載
	IEC 教材の改訂	完了、FR に記載
斜面崩壊、落石、土石流対策を踏まえた斜面災害防止区域（開発計画政策指針(PPG)土地利用規制）の更新支援	PPG の改定状況確認	2016 年３月改訂
	実際の開発規制状況とリスク削減効果の評価・分析	評価・分析実施（HML により活用が進んでいる）
	3 災害を網羅した形での PPG 改定案の提示	マニュアルとの連携提案

MPI/LMU（地すべり対策ユニット）の組織強化の継続支援（既往案件提案内容の実施・定着状況の確認及び実施に係る追加技術支援）	判断基準の明確化の重要性確認、組織強化計画	GEO（地盤工学技術オフィス）に主要組織を集約する。マンデートは従来の提案内容を踏襲する
	組織の責任範囲、役割分担	LMU への技術移転成果は GEO へ引き継ぐ。組織の責任範囲、役割分担は GEO のマンデートに記載される
	LMU 以外の関係機関向け教材作成支援	モーリシャス政府全体の広報セクション（GIS）と協働しツールを開発した。MPI 広報担当者が配属され次第 GIS より引継ぎを行う
	他の防災機関との連携と役割確認	従前の体制を維持。GEO のマンデートに記載

これらの成果は技術移転主要成果概要実績一覧表ならびにプロジェクト成果毎の対処結果表を示す（表 3、表 4)。

２．２　　投入実績

各専門家の投入実績を図 2 に示す。

２．３　　業務フローチャート

業務のフローチャート図 3 に示す。

表 3　技術移転主要成果実績表

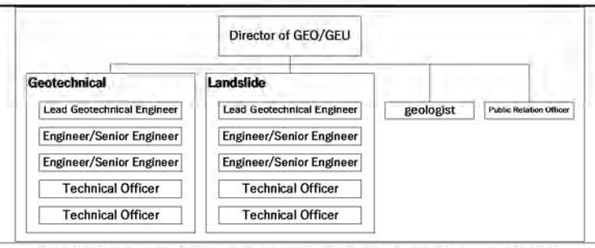
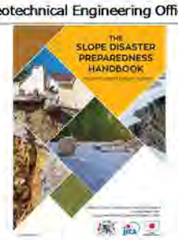
項目（支援内容）		準備調査手法	調査・解析	設計・施工	維持管理	（事業）評価	概要説明
斜面災害対策	地すべり						・地すべりの調査・モニタリング・対策工の設計/施工/維持管理および対策工実施後の評価方法について分かりやすく解説した。 ・LMUメンバーのみならず、地方行政の技術者が理解しやすいように、現場写真を地元のものにした。 ・PJ終了後に直ちに実施するべき作業（対策工の評価と維持管理、斜面マッピング）について別冊の手順書を追加作成し、今後の利用促進が進むよう配慮した。
		GISを用いた斜面マッピング	初期調査技術ガイドライン（フェーズII成果に加筆修正）	地すべり対策実施マニュアル（フェーズII成果に加筆修正）	地すべり対策工事の維持管理手順	安定解析を用いた対策工の評価手法	
	斜面崩壊・落石・土石流						・斜面崩壊・落石・土石流の調査・モニタリング・対策工の設計/施工/維持管理および対策工実施後の評価方法について分かりやすく解説した。 ・LMUメンバーのみならず、地方行政の技術者が理解しやすいように、現場写真を地元のものにした。 ・PJ終了後に直ちに実施するべき作業（斜面マッピングと落石インベントリー調査）について別冊の手順書を追加作成し、、今後の利用促進が進むよう配慮した。
		GISを用いた斜面マッピング	斜面崩壊、落石及び土石流調査及び対策工マニュアル　（付録：落石インベントリー調査マニュアル[Signal Mountainを例に]）				
モニタリング・予警報システム提案内容							
斜面災害モニタリング体制構築/早期警戒システム・避難手順							・前PJで導入した地すべりEWSを増設するとともに、EWS簡単セッティングマニュアルを作成し、今後の増設や維持管理を容易にした。 ・現地データ通信(携帯電話網)に最適化したモーリシャス用リモートモニタリングシステムを設計・提案。 ・斜面防災用の雨量観測の一手法として、MMS（モーリシャス気象サービス）が運用するAWS（自動気象観測システム）を導入した。
		地すべりEWS		EWS簡単セッティングマニュアル	リモートモニタリングシステム	AWS（自動気象観測システム）	
PPG-土地利用規制の更新		PPGの改訂は2016年3月に実施された。利用土地規制については更なる詳細マッピング（レッド、イエローゾーンの同定）が必要ではあるものの、斜面地域の開発は上記マニュアルを併用して進める旨、MPI、HMLの間で協議された。					
組織強化・防災教育支援							
組織強化							・LMUのMandateやRegistered Engineerとしての取扱で健在化したため、組織体そのものの抜本的な見直しを行った。 ・組織強化対象として従来のLMUに対してそのまま実施した。現地調査業務にてマニュアル内容の解説を行った。 ・GEOには技術移転したLMUのメンバーが入ることとなり、移転技術の継続性は確保された。 ・GEOの設立によって上述の課題を払拭することとなった。GEOの設立について大臣が公言（TV）し実質的な作業に入った（組織・人員のTOR作成）
		1990年代-2013年までの体制	2013年-2017年LMU体制検証	地質工学技術局=GEO（Geotechnical Engineering Office）（仮称）の組織体制-将来			
防災教材作成支援		既存資料の概要 - 地すべりのみ - 英語・フランス語（24ページ） - 文字数、専門用多用		1. 既存資料の検証 2. 関係省庁に内容の妥当性検証 3. アップデート方針 - 斜面災害4種 - 英語・フランス語（8ページ） - クレオール（1枚折り込み） - 項数、文字数、専門用語減 - 現地写真、イラスト、役立つ情報の取り込み			・12月6日のワークショップ/セミナーにおいて、正式な引渡しが行われ、関係省庁・学校・公共施設等に配布した。 ・斜面災害危険地域の住民に対しては、啓発活動を行った上で配布する。 ・本プロジェクト実施中に広報担当官が配属されなかったが、政府の広報活動を担うGovernment Information Service（GIS）の全面的な協力により、教材改訂・作成作業を実施した。 ・GEOに広報担当官が配属されるまではGISが斜面災害の広報活動をサポートし、配属され次第GISから広報に係る技術移転が行われる。
		2015年作成教育教材	（英語版・全24ページ）	今回作成した教材	（英語版-全8ページ）	クレオール版-1枚裏表三つ折り）	

表 4　プロジェクト成果毎の対処結果表

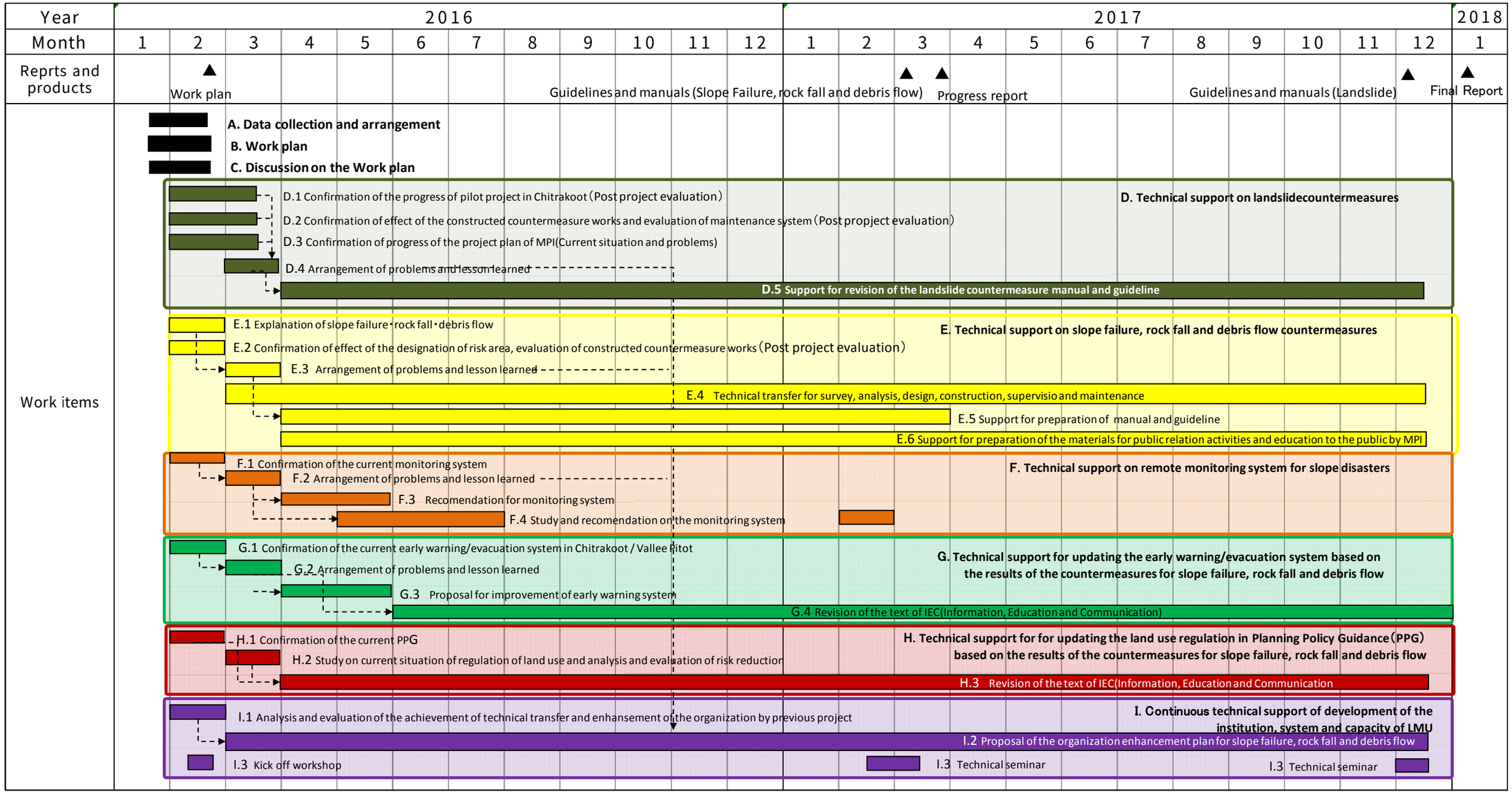
プロジェクト実施内容（支援内容）当初計画		契約（計画）変更後	既実施内容	成果品	課題・実情	対処
1	地すべり対策の「維持管理」及び「事業評価」	対策工実施後に最終とりまとめ	第二期工事完了後に追加 LMUの体制変更に伴い、現状に合わせて緊急対応手順を大幅に修正した。	「初期調査の技術ガイ ドライン及び実 務手順書（地すべ り対策マニュアル） の改定案」	Chitrakootでの対策工事が優先事業として特定され、パイロット事業の第一期工事を実施した。本個別専門家派遣においては、前回実施できなかった追加の対策工事を第二期工事として先方政府予算にて実施する過程で、OJT形式にて個別専門家から技術支援を行うことを想定し、その内容を地すべり対策マニュアルに反映した。	現在の情報では7月後半着工し、12月中旬で70%の進捗状況。すでに主要工事種目はJETによるサポートが完了している。完工は年明けになる見込み。
2	斜面崩壊対策の「調査・解析 ・設計・施工・維持管理・事業評価」	対策工実施後に最終とりまとめ	OJT、小規模セミナー、現地視察などを通じた対策支援の実施	「初期調査の技術ガイ ドライン及び実 務手順書（斜面崩壊対策マ ニュアル） （案） 」 斜面崩壊、落石、土石流を一冊にまとめる。	対策工の実施はBatelage道路斜面に限られる。 すでにマニュアルは完成している	Batelage道路斜面の工事は2017年乾季の完成となるため、施工、施工監理のOJT、評価を行うことができる。状況を確認しつつ日本の事例などを参照して施工・維持管理・事業評価を提言
3	落石対策の「調査・解析 ・設計・施工・維持管理事業評価」	対策工実施後に最終とりまとめ	OJT、小規模セミナー、現地視察などを通じた対策支援の実施	「初期調査の技術ガイ ドライン及び実 務手順書（落石対策マニュアル） （案） 」 斜面崩壊、落石、土石流を一冊にまとめる。	Maconde、Signal Mountainが主なサイトで、調査、設計は終了している。工事発注は遅れている。 OJT、小規模セミナー、現地視察などを実施しており、マニュアルは完成している	Maconde、Signal Mountainの工事は2017年度内の発注が難しい。施工、施工監理のOJT、評価が実施出来ない可能性があるため、状況を確認しつつ日本の事例などを参照して施工・維持管理・事業評価を提言
4	土石流対策の『調査・解析・設計・施工・維持管理事業評価」	対策工実施後に最終とりまとめ	OJT、小規模セミナー、現地視察などを通じた対策支援の実施	「初期調査の技術ガイ ドライン及び実 務手順書（土石流対策マニュアル） （案） 」 斜面崩壊、落石、土石流を一冊にまとめる。	Baie de Capのみが土石流サイト OJT、小規模セミナー、現地視察などを実施しており、マニュアルは完成している	RDAがすでに工事を終えており、マニュアル等により、施工・維持管理・事業評価を提言
5	斜面災害に係る遠隔モニタリング体制構築	変更無し	携帯電話通信を利用した遠隔モニタリングシステムを、ChitrakootやVallee Pitotをモデルに設計・提案した。	モニタリング計画案をFINAL REPORTに記載	LMUは遠隔モニタリング体制構築に係る予算措置が出来ていない。GEO設立に伴い機器材購入計画を策定する	「モニタリング計画(案） 」を実際に実施するに際して必要な資機材や設置業者について、日本のメーカーや地元設置業者の能力を検討し、対応可能なメーカーや地元設置業者をLMUに紹介して、今後、LMUが予算を確保でき次第、容易に交渉・発注し遠隔監視体制を構築できるようにしておく。
6	斜面崩壊、落石、土石流対策を踏まえた早期警報システム ・避難手順の更新	変更無し	自動雨量観測システムを2か所に導入し、警戒避難のための雨量観測の自動化を進めた。ポートルイス市内のシグナルマウンテン地区で、OJT研修を実施し、落石調査・警戒体制（通行止め・立入禁止） ・看板設置等々の技術移転を実施した。	早期警報システム・避難手順更新案をFINAL REPORTに記載	斜面崩壊、落石、土石流に係る早期警報 ・避難を行うには、ハザードマップの作製が不可欠だが、モーリシャスには実用に足る精度のハザードマップがない（AAPが作成したものはあるが解像度は低く実用に足りない） 。 また、斜面崩壊、落石、土石流に係る災害記録やその時の雨量記録が殆どなく、計画避難雨量の設定ができない。	モーリシャスにある最も精度の高いDEM（デジタル標高データ）を用い、GISを使ったハザードマップの作製方法を施術移転する。具体的には、無料のGISソフト（Q-GIS）を使ったワークショップを9月・10月に開催する予定。合わせて、警戒避難雨量の設定方法もレクチャーした。
7	斜面崩壊、落石、土石流対策を踏まえた斜面災害防止区域 （開発計画政策指針 （ PPG: Planning Policy Guidance） の土地利用規制） の更新	変更無し	2016年3月、前プロジェクトの提案が反映されたPPG Ver9が発効している	斜面災害防止区域の更新は特にせず	本内容は前プロジェクト後の、斜面災害エリアの特定と過去の災害実態調査に基づく危険エリアの同定が前提となっているが現段階ではAFPで策定されたDRRレポートを参照する以外の方法は無い	更新に向けてのステップをフローで示すことにより、「更新のための必要作業内容」を上記作業に準じてレクチャーした。
8	MPI/LMU （地すべり対策ユニット） の組織強化の継続 （既往プロ ジェクト提案内容の実施・定着状況の確認及び実施に係 る追加技術支援）	判断基準の明確化の重要性	基準案が策定され、議会にかけられることとなっていたが、実行されなかった	組織能力強化計画の更新案をFINAL REPORTに記載	大臣をはじめとするMPIトップが必要性を認識しており、GEOの設立を公的（TV）で言及。MPI/DPS、MPI/CESダイレクターともにJICAより技術移転を受けたメンバーをGEOのサポートまたは要員とすることに言及している。LMUに代わる地質工学機関GEOの設置を推進しており、メンバー国内での採用、国際枠での採用を進めている。	GEOの将来計画策定案を提示。
		組織の責任範囲、役割分担	日本事例紹介、ワークショップを通じた問題意識共有、役割分担案の作成、コメントの取りつけと役割分担（案）の作成・更新	役割分担案をFINAL REPORTに記載		LMUとして技術移転を受けたメンバーが最低限にMPI内での引継ぐ。LMU、GEOを問わず斜面災害防止所轄官庁としての立場を明確化する。
		LMU以外の関係機関向けの教材作成支援	基本的な改訂作業は完了	「IEC 教材更新 （案） 」	現時点では広報担当C/Pが不在である（DPSがこれに相当との認識）ため移転先が不明確となったまま推移している。	MPIの広報セクションGISが対応。採用予定の広報担当者へはGISが引き継ぐ
		他の防災機関との連携と役割の確認	セミナーにて協力関係を進めたいとの打診が消防局よりあった	「IEC 教材更新 （案） 」	災害時にはじめに対応するのは消防局であり、局側は教材の普及に協力姿勢を見せている	

図 2　専門家の投入実績

	担当業務	格付		渡航回数	契約期間 2016 1	2	3	4	5	6	7	8	9	10	11	12	2017 1	2	3	4	5	6	7	8	9	10	11	12	2018 1	日数合計	人月合計
現地業務	市川　建介（総括／斜面災害対策）	2	当初計画	6		(30日)			(40日)				(35日)			(30日)		(49日)									(27日)		211	7.03
			現行計画	7		(18日)		(13日)		(40日)			(35日)					(63日)						(47日)				(25日)		241	8.03
			実績	7		1/27 2/13 5 13		4/10 4/22 13	5/9 6/17 23 17				9/12 10/16 19 16					1/11 3/14 21 28 14						7/10 8/25 22 25				11/21 12/15 10 15		241	8.03
	塚本　哲（調査設計）	3	当初計画	4		(30日)				(35日)					(45日)			(37日)												147	4.90
			現行計画	4		(30日)				(35日)				(45日)							(45日)									155	5.17
			実績	4		2/8 3/8 22 8				6/15 7/19 16 19				10/2 11/15 30 15						4/11 5/25 20 25									155	5.17
	岩崎　智治（施工維持管理）	3	当初計画	4			(30日)				(40日)				(40日)			(39日)												149	4.97
			現行計画	6			(30日)				(40日)			(40日)				(14日)						(32日)			(14日)			170	5.67
			実績	6			3/4 4/2 28 2				7/11 8/19 21 19			10/14 11/22 18 22				2/27 3/12 2 12						9/17 10/18 14 18			12/4 12/17 14			170	5.67
	吉田　悠（組織強化）	4	当初計画	4				(30日)				(35日)				(30日)												(22日)			117	3.90
			現行計画	5				(15日)								(25日)		(45日)						(35日)				(27日)			147	4.90
			実績	5				4/2 4/17 15								12/1 12/25 25		2/5 3/21 24 21						8/10 9/13 22 13				11/19 12/15 12 15			147	4.90
																													現地業務小計 当初計画	624	20.80
																													現行計画	713	23.77
																													実績	713	23.77
国内業務	市川　建介（総括／斜面災害対策）	2	当初計画						(5日)					(5日)				(5日)										(5日)			20	1.00
			現行計画						(5日)					(5日)				(3日)			(2日)							(5日)			20	1.00
			実績						4/25 4/30 5					10/17 10/21 5				1/8 1/10 3			3/21 3/22 2							1/9-1/13 5			20	1.00
	塚本　哲（調査設計）	3	当初計画			(5日)								(5日)							(5日)							(5日)			20	1.00
			現行計画			(5日)								(5日)					(5日)									(5日)			20	1.00
			実績			2/1 2/5 5								9/26 9/30 5					2/13 2/17 5									12/18 12/22 5			20	1.00
	岩崎　智治（施工維持管理）	3	当初計画											(5日)							(5日)										10	0.50
			現行計画											(5日)					(5日)												10	0.50
			実績											10/3 10/7 5					2/20 2/24 5												10	0.50
																													国内業務小計 当初計画	50	2.50
																													現行計画	50	2.50
																													実績	50	2.50

凡例：　業務従事実績　　業務従事計画　　自社負担

図 3　業務のフローチャート



第３章　活動実績

活動実績を成果毎に実績一覧表にとりまとめた。

	日付	タイトル	実施内容	組織 (参加人数)	MPI/LMU	章節	参考/成果
チトラクートパイロットプロジェクト	2017年3月8日	Chitrakootのフェーズ１対策工事の現状調査	MPI/LMU と JETは、Chitrakootにおける地すべり対策：フェーズ１ の現状を確認し、写真に記録した	MPI（2）	・現状の理解 ・地すべりマニュアルの活用(Procedure Manual for Landslide) ・OJT　(On the Job Training)	3.1.1	Appendix. 3.1.1
	2016年8月17日	第1回フェーズ2工事のための関係者会議	・フェーズ２対策工事の重要性の説明 ・対策工範囲の土地所有者の承諾を得る	MPI(3), NDRRMC(1), MHL(1), Other Authority (4), LOCAL Authority (1), Inhabitant(25)			Appendix. 3.1.2
	2016年10月26日	第2回フェーズ2工事のための関係者会議	プロジェクトの最終計画とその緊急性を住民に説明	MPI(3), NDRRMC(1), MHL(1), LOCAL Authority (1), Inhabitant(8)	・地すべり対策工事の事前調整手順の確認 ・情報共有の効果的な手法		
	2017年8月17日	第3回フェーズ2工事のための関係者会議	・チトラクート第2期工事の説明（目的、工期、実施内容等） ・質疑応答	MPI-HQ(2)、MPI(7)、others(7)、Inhabitant(12)			
	2017年7月6日	第1回現場会議（MPI主催）	地すべり対策工の工程確認と懸案事項に関する協議	MPI(10), MHL(2), NDRRMC(1), Local Authority (1), Contractor(4), Others(7)	・施工管理 ・地すべりマニュアルの活用(Procedure Manual for Landslide) ・OJT　(On the Job Training)		Appendix. 3.1.3
	2017年9月7日	第2回現場会議（MPI主催）		MPI(6), Contractor(2)			
	2017年9月28日	第3回現場会議（MPI主催）		MPI(6), Contractor(6)			
	2017年10月26日	第4回現場会議（MPI主催）		MPI (4), Contractor(4)			
	2017年12月7日	第5回現場会議（MPI主催）					
	2017年9月20日	施工管理のための技術的アドバイス(1)	施工期間を通じて、JICA専門家から地すべり対策工の施工管理に関する技術的アドバイスを行った	MPI（4）、Others(3)	・施工管理 ・地すべり対策工の施工管理に関する技術移転 ・OJT(On the Job Training)		Appendix. 3.1.4
	2017年9月27日	施工管理のための技術的アドバイス(2)		MPI（6）、Others(11)			Appendix. 3.1.5
	2017年12月7日	施工管理のための技術的アドバイス(3)		MPI（2）			Appendix. 3.1.6
	2017年12月15日	Chitrakootのフェーズ2対策工事の現状調査	Chitrakootにおける地すべり対策：フェーズ2 の現状を確認・写真記録	MPI（2）	・現状の理解 ・地すべりマニュアルの活用(Procedure Manual for Landslide) ・OJT　(On the Job Training)		Appendix. 3.1.7
対策孤高事業評価及び維持管理システム	2017年3月6日	対策工のメンテナンスのための現地調査	MPI/LMUとJETによって、チトラクートの排水工の現況調査が行われた。.	MPI(2)	・地すべり対策工のメンテンナスのための現地調査方法の技術移転 ・OJT(On the Job Training)	3.1.2	Appendix 3.1.1 Appendix. 3.1.8
	2017年10月17日	地すべり対策工のメンテナンスの手順書作成	MPI/LMUとJETによって、地すべり対策工のメンテナンスのための手順書が作成された。	MPI(5)	・メンテナンス方法の技術移転 ・地すべり対策工のメンテナンス手順書「Procedure of the Maintenance for Landslide Countermeasures」の		Appendix 3.1.9
	2017年10月17日	テクニカル・ミーティング	MPI/LMUとJETは、地すべり対策工のメンテナンスのための技術ミーティングを開催した。	MPI(5)	・地すべり対策工のメンテナンス手順の技術移転 ・メンテナンス手順書の理解		Appendix. 3.1.10
	2017年12月15日	テクニカル・ワークショップ	JICA専門家によって、安定解析を用いた地すべり対策工の効果判定手法がMPIに技術移転された。また、MPIとJICA専門家によって、安定解析を用いた地すべり対策工の効果判定手法の解説書が作成された。.	MPI(15)	・技術移転：安定解析を用いた地すべり対策工の効果判定手法 ・解説書「Evaluation method for effects of the landslide countermeasure by using Stability Analysis」の活用		Appendix 3.1.11 Appendix 3.1.12
	2017年12月15日	対策工の効果判定の作業計画書	MPIは、マニュアルを参考にして、Chitrakootにおける地すべり対策工の評価作業計画書を作成した。	MPI(2)	・技術移転：安定解析を用いた地すべり対策工の効果判定手法 ・解説書「Evaluation method for effects of the landslide countermeasure by using Stability Analysis」の活用		Appendix 3.1.13
マニュアル活用	2015年5月5日	Vallee Pitotでの地すべり調査	マニュアルを使用して、MPIがVallee Pitotにて地すべり調査を独自に実施した。	MPI(3)	・地すべりマニュアルの活用(Procedure Manual for Landslide)	3.1.3	Appendix 3.1.14
	2017年7月6日	Chitrakootでの対策工の詳細設計	マニュアルを使用して、MPIがChitrakootの地すべり対策工の設計を実施した。	MPI(3)	・地すべりマニュアルの活用(Procedure Manual for Landslide)		Appendix 3.1.15
	2017年7月6日	Chitrakootでの対策工の施工	マニュアルを使用して、MPIがChitrakootの地すべり対策工を施工した。	MPI(3)	・地すべりマニュアルの活用(Procedure Manual for Landslide)		Appendix 3.1.1 - 3.1.7
	2017年10月12日	Vallee Pitotでの対策工の施工	マニュアルを使用して、MPIとRDAがVallee Pitotの地すべり対策工を施工した。	MPI(3)	・地すべりマニュアルの活用(Procedure Manual for Landslide)		Appendix 3.1.16
	2017年10月17日	地すべり対策工のメンテナンスの手順書作成	MPI/LMUとJETによって、地すべり対策工のメンテナンスのための手順書が作成された。	MPI(5)	・地すべり対策工のメンテナンス手順書の作成 ・メンテナンス手法の理解		Appendix 3.1.9
斜面崩壊、落石、土石流対策	2016年3月3日	テクニカル・ミーティング (1)	Agenda of Tec ・斜面災害の特徴/斜面災害の原因/対策工/低コスト対策/枠組工の説明	MPI(5)	・斜面崩壊、落石、土石流の基本的な知識 ・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock	3.2.1	Appendix 3.2.1
	2016年7月14日	テクニカル・ミーティング (2)	落石の説明（シグナルマウンテンの例）/構造物対抗策/ PPGについて/落石対策	MPI(5)	・Basic knowledge of slope failures ・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock		
	2016年7月20日	テクニカル・ミーティング (3)	落石の対策工/対策工の材料/ Macondeとシグナルマウンテンのための基本的な計画	MPI/LMU, RDA, NDRRMC, Contractor (27 participants)	・ 落成対策工の習得 ・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow」の活用		
リスク地域同定と対策工評価	2016年10月31日	斜面インベントリー	MPI と JETは 18現場を調査し、 面崩壊、落石、土石流の斜面インベントリーを作成した	MPI(5)	・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow」の活用	3.2.2	Appendix 3.2.2
	2016年10月31日	斜面点検シート	MPIとJETは 18現場の斜面点検シートを作成した。	MPI(5)	・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow」の活用		Appendix 3.2.3
	2016年10月31日	既存の斜面対策工の効果（評価）	既存の斜面対策工は2斜面で認められた。そしてそれらの効果は評価された。	MPI(5)	・斜面崩壊、落石、土石流マニュアル「 Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow」の活用		Appendix 3.2.4
	2017年10月11日	Technical workshop	JET は斜面傾斜図の作成方法のための技術移転ワークショップを開催した。将来、高精度のDEMが入手されたら、このワークショップの技術を使って、MPIはハザードマップとしての高精度斜面傾斜図を容易に作成できる。	MPI(15)	・斜面傾斜図の作成手順の技術移転 ・斜面傾斜図の作成手順書「 Procedure for elaborating a slope map in QGIS」の活用		Appendix 3.2.5

	日付	タイトル	実施内容	組織（参加人数）	MPI/LMU	章節	参考/成果
斜面崩壊、落石、土石流マニュアル策定とその利用	2016年2月15、17、23日、7月7日、10月7日、2017年9月26日	マニュアルを使った技術移転： Batelage	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・ 斜面調査を実施 ・崩壊の分類と主因特定 ・対策工の設計	MPI(2), NDRRMC, Savanne District Council, Police Office and RDA	・マニュアル「Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow」を使った技術移転 ・OJT(On the Job Training)	3.2.3	Appendix 3.2.6
	2016年6月21、22、27、7月5日、12日、19日、8月1日、5日、10月24日、26日	マニュアルを使った技術移転： Signal Mountain	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・斜面調査を実施 ・落石、道路面沈下、土石流が分布 ・落石タイプの分類とメカニズム解明 ・土石流と浸食のメカニズム解明 ・落石調査および対策工の設計	MPI(2), NDRRMC, SMF			
	2016年7月21日、26日、10月25日、11月4日、7日、2017年9月26日	マニュアルを使った技術移転： Maconde	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・ B9 道路沿いの急崖調査 ・落石対策の設計	MPI(4)			
	2016年10月21日	マニュアルを使った技術移転： Hermitage	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・MPIは斜面調査を実施 ・斜面崩壊の原因は土地開発（無許可）であった	MPI(2)			
	2016年6月21日、22日、27日	マニュアルを使った技術移転： Mount Ory (M1)	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・モカ地区評議会は、MPIに斜面調査を依頼した ・レーザー測距儀での地形調査を実施 ・斜面勾配は、PPGで規制される20%であった。	MPI(2)			
	2016年3月29日	マニュアルを使った技術移転： Mount Ory (Moka)	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・モカ地区評議会は、MPIに斜面調査を依頼した ・レーザー測距儀での地形調査を実施 ・斜面勾配は、PPGで規制される20%であった。 ・ 背後斜面は落石の危険がある	MPI(2)			
	2016年2月27日、5月24日、7月7日	マニュアルを使った技術移転： Ruisseau Créoles	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・落石調査を実施。 ・複数の転石が、住宅背後の斜面にある。 ・斜面勾配が15～20度で、落石が家屋に到達する可能性あり。	MPI(2)			
	2016年8月9日	マニュアルを使った技術移転： Camp Garreau, Flacq	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・ 斜面調査を実施。 ・斜面崩壊の原因は生活排水と雨水および河川による浸食である	MPI(1)			
	3 and 4 March 2016, 29 March 2016	マニュアルを使った技術移転： Kewal Nagar	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・斜面調査を実施。 ・斜面崩壊は、河川浸食と人工的な地形改変が原因 ・幅数メートルの人工の段差が認められた。 ・斜面の地質は、非常に風化した岩と粘土質の土である。	MPI(1)			
	2017年10月24日	マニュアルを使った技術移転： Coromandel	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・落石調査を実施 ・多くの不安定な転石が急斜面にある。	MPI(1)			
	29 February 2016, 3 March 2016	マニュアルを使った技術移転： Petit Bel Air	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・斜面調査を実施した ・斜面の地質は、非常に風化した岩である。	MPI(1)			
	16 February 2016, 26 February 2016	マニュアルを使った技術移転： Vallée Pitot	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・斜面調査を実施した。 ・現場は山麓に位置し、市街膨張の開発圧力が大きい ・斜面崩壊は、山腹斜面からのフラッシュフラッドと道路盛土材からの湧水に起因する ・主な被害は、洪水と擁壁および道路の崩壊である	MPI(5)			
	8 July 2016, 15 July 2016	マニュアルを使った技術移転： Long Mountain	JETのアドバイスを受けてMPIは以下の作業を実施した。 ・斜面調査を実施 ・問題の斜面は、河川浸食の影響を受けている ・斜面の被害は、河川ではなく住宅地からの表流水である。 ・家の基盤は、わずかに洗堀されている。	MPI(1)			
	2016年8月12日	MPIの各種資料作成のサポート	・ Signal Mountain:落石プロトコル作成のサポート ・ Maconde: 落石対策資料作成のサポート ・ Batelage: 道路切土対策資料の作製のサポート	MPI(3)	・ Signal Mountain: 資料 “ Manual for Rock Fall Inventory at Signal Mountain Road”を作成 ・ Maconde: 道路線形・落石防止フェンス・落石防護ネットの詳細設計資料を作成 ・ Batelage: 法枠工・ロックボルト・吹付けコンクリートおよび擁壁工の詳細設計資料を作成		Appendix 3.2.7
モニタリングシステム、早期警戒	2017年3月8日	既存のモニタリングシステム	MPIとJETは、各現場に導入されている既存のモニタリングシステムの状況を調査・確認した	MPI(3)	・現状の理解 ・地すべりマニュアルの活用(Procedure Manual for Landslide)	3.3.1	Appendix 3.3.1
	2016年8月12日	リモートモニタリングシステムの提案	JETとMPIは、モーリシャス向けのリモートモニタリングシステムを提案した。	MPI(3)	・リモートモニタリングシステムの計画立案 ・モーリシャス向けの内容を検討	3.3.4	Appendix 3.3.2
	2016年8月12日	Chitrakoot と Vallée PitotのEWS	伸縮計と警報機から成る地すべり用のEWSは、 既存プロジェクトにおいてChitrakootと Vallée Pitotに導入され、追加のEWSは2015年にMPI自身の手によって追加導入されている.	MPI(3)	・地すべりマニュアルの活用(Procedure Manual for Landslide) ・地すべり用EWSの計画と導入	3.4.1	Appendix 3.4.1
	2016年3月29日	EWSの簡単セッティングマニュアル	EWSの機器メンテナンスのために、「EWSの簡単セッティングマニュアル」が MPI と JETによって作成された	MPI(2)	・地すべり用EWSの理解 ・メンテナンス技術の習得	3.4.2	Appendix 3.4.2
	2017年3月6日	自動雨量モニタリングシステム(MMSのAWSの利用)	MPIからの要求を受けて, MMS（モーリシャス気象サービス）は、AWS（自動気象ステーション）をチトラクートに導入した.	MPI(3)	・広域の自動の雨量監視システムの計画 ・MMSのAWSの利用によるコスト削減と簡単なオペレーション	3.4.3	Appendix 3.4.2

第４章　技術移転による成果

４．１　　斜面災害対策の技術移転にかかる成果

前表にとりまとめたとおり、成果は大きく以下の 4 活動に集約される。また、斜面災害サイト毎の活動表にとりまとめた。個別の詳細な成果については、APPENDIX1 FR に示した。

1)　斜面災害対策（地すべり、斜面崩壊、落石、土石流）のマニュアル策定・OJT による C/P に対する技術指導

- 地すべりマニュアルの修正・改訂（GIS を用いた斜面マッピング解説書、初期調査技術ガイドライン、地すべり対策実施マニュアル、地すべり対策工事の維持管理手順及び安定解析を用いた対策工の評価手法
- 斜面崩壊、落石及び土石流調査及び対策マニュアルの作成
- 上記マニュアル類を用いた現地での調査・設計・施工・維持管理の OJT と説明
- チトラクート第二期工事の施工・維持管理活動支援の実施

2)　モニタリング・予警報システムの提案

- 地すべり EWS（早期警戒システム）の簡易セッティングマニュアルの策定
- リモートモニタリングシステムの提案
- 斜面防災用自動気象観測システムの提案と導入

3)　PPG 土地利用規制の更新

- PPG 改訂（2016 年 3 月第 9 版が発効）
- 斜面地域開発におけるマニュアルの活用提案

４．２　　組織強化・防災教育にかかる支援の成果

組織強化・防災教育にかかる成果は以下のとおりである。

1)　組織強化

- LMU のマンデート、人材配置計画案策定
- MPI、LMU との組織強化にかかる協議と方向性の確認
- GEO 設立のために必要な支援の実施（組織体制、人材育成にかかる提案）
- セミナーの開催による組織強化策の提示

2)　防災教育

- GIS との協働による防災教育活動の実施
- 斜面災害ハンドブックの作成

表 5 各サイトで実施した技術移転内容

サイト	原因調査に関する指導・協議内容	対策についての指導・協議内容
1 Batelage（道路 cut slope failure）	➢ 道路セクションごとに failure タイプを特定した。 ➢ Slope failure 原因は 2015 年の暴風雨と強風 ➢ 住宅には変形や亀裂などの被害は出ていないが、住宅からの雨水、下水の slope への排水が問題となる。	➢ 不安定な樹木の伐採、不安定 slope の成形、unstable rocks の除石 ➢ 現場打ち crib wall 工、ソイルネイリング、ロックボルト、吹き付け、待ち受け式のコンクリート retaining wall ➢ 住宅排水対策の必要性
2 Signal Mountain（rock fall、debris flow）	➢ 延長約 3km で rock fall、路肩盛土部沈下、debris flow が発生している。 ➢ rock fall・slope のタイプ分けをした。 ➢ 路肩盛土部沈下箇所と debris flow 危険渓流の存在 ➢ rock fall 発生の原因およびメカニズムについて検討を行った。	➢ rock fall 対応プロトコル案を作成した。 ➢ rock fall 点検調査計画を共同作成した ➢ rock fall インベントリマニュアルを作成した。 ➢ ソフト rock fall 対策は情報板、危険標識、通行規制など ➢ ハード rock fall 対策は岩塊の除去工、固定・安定化工、道路沿いでの保護工 ➢ SMF の調査員に、Signal Mountain rock fall インベントリの実地トレーニング（OJT）を行った。
3 Maconde（rock fall）	➢ 国道 B9 沿いの rock fall 危険個所。 ➢ 溶岩の互層からなる急崖で、過去にも rock fall が頻発している。	➢ RDA が道路アライメントの変更、簡易な rock fall 対策（フェンス）、除石を実施した。 ➢ rock fall 対策プロトコルを作成協議 ➢ 表示板や説明パネル、サイクロン時の警戒・避難、通行規制など ➢ LMU と JET がコスト積算、工事仕様の検討を行った。
4 Hermitage（slope failure、rock fall）	➢ slope 改変状況、failure 危険性、道路及び住宅へのリスクの調査が行われた。 ➢ 不適当な開発がトリガーとなっている。	➢ retaining wall、rock fall 防止柵、排水路の設計 ➢ LMU と JET で countermeasure works の現地確認を行った。
5 Mount Ory（M1）	➢ District Council から LMU への、緊急調査依頼 ➢ レーザー測器による地形測量 ➢ 上部が slopeingredient20%以上というぎりぎりの傾斜	➢ LMU が現場調査報告書を作成した。 ➢ slopeingredient20％を超える境界を明確にする。
6 Mount Ory (Moka)	➢ District Council から MPI/LMU に「slope での土地使用許可申請」に対する現地視察の要請があった。 ➢ レーザー測器による傾斜測量 ➢ 背後は急 slope があり、rock fall 災害の危険性がある。	➢ この土地の開発前の推定 ingredient は、20%以上と推定される。 ➢ rock fall の危険性が高く、開発行為は許可しない。 ➢
7 Ruisseau des Créoles（rock fall）	➢ 住宅の敷地には直径 1 m以下の巨礫が散在している。 ➢ これらの岩塊は slope 上にもともとあったもののほか、背後のサトウキビ畑からの slope に捨てられたものである。	➢ LMU と JET が現地調査を行い、rock fall の危険性と対策について協議した。 ➢ 除石と固定化で対応する。

	➢ rock fallのタイプとしては、転動する抜け落ち型のrock fall が多い。 ➢ slope の傾斜が 15 から 20 度で、転動距離はさほど大ききはならないと判断された。	
8 Camp Garreau, Flacq（河川浸食崖の failure）	➢ 崖の failure は river erosion と、生活排水および雨水による surface erosion が原因と考えられる。	➢ countermeasure works 費が相当高額になると予想されることから、MPI/LMU は災害対策として家屋移転を推奨する方針
9 Kewal Nagar/ Belle Rive（river erosion）	➢ 河川の崖で、一様な傾 slope ではなく、人工的な段差、河岸近くには堆積による数 m 幅の平坦地がある。 ➢ 地質は風化の進んだ粘土質の土質で、風化岩部分と風化粘土の部分が混在している。	➢ MOESDDBM も現地を訪れ、政府としての対応をコメントした経緯がある。 ➢ 河川と slope についての土地条件と住宅への危険性評価について、協議した。 ➢ LMU は Gabion による浸食防止対策を行う方針とした。 ➢
10 Coromondel（slope failure）	➢ 急 slope には多量の不安定な転石があり、rock fall が発生する可能性がある。 ➢ 降雨時には土地の上方にある道路から雨水が流れ込んでいて、slope を不安定化している。 ➢ この用地には傾斜 30 度以上の急傾 slopeと平坦面があり、住宅は平坦面上に建設される計画である。	➢ 転石除去工、retaining wall 工、待ち受け retaining wall、排水溝の整備する。 ➢ 禁止事項として slope の切り取りや掘削は厳禁
11 Pitit Bel Air（cut 切土 slope failure）	➢ River des Creoles の河口近くにある住宅背後の切土 slope である。 ➢ 下位の住宅建設のために、掘り出しやすい強風化の basalt を重機で掻き出した。 ➢ 原因は slope 下方の住民の不適切な掘削によるものである。	➢ 上方の住民の水処理について調査したが、特に問題はない。
12 Vallée Pitot（bank slope failure盛土failure対策）	➢ 対象箇所は slope 下部の住宅開発箇所である。 ➢ 強雨によるフラッシュフラッドと盛土の failure が発生した。 ➢ 被害は周辺の住宅の浸水、盛土 retaining wall の failure、それに伴う道路陥没、コンクリートブロック retaining wall が押し出された。	➢ フラッシュフラッド対策 ➢ 整備不良の道路盛土の改良 ➢ 不良排水施設の改善と retaining wall の強度増 ➢ slope を含む流域管理の考え方が必要である。
13 Long Mountain（住宅背後の河岸 slope failure）	➢ 河川の崖に接近した住宅の下方の slope failure とそれによる基礎の洗い出し	➢ 住宅からの表流水対策 ➢ 基礎の補強で対応

第５章　全体総括

５．１　　運営上の課題

プロジェクト運営上最大の課題は、C/P に対する技術的内容の理解や移転の方法論では無く、C/P 機関として斜面災害に対応する LMU の組織体制が十分に確立されていない事にある。実態として今までの組織の実施体制、役割分担が不明確であったことであり、MPI 全体として斜面災害対策を十分に理解していなかった事が最大の原因だったと考えられる。以下にその課題の整理を行う。

1)　　LMU（C/P）の課題及び問題点

プロジェクト実施にあたって、LMU 組織変遷とその過程における課題、問題点を整理すると下表のとおりとなる。

表 6　LMU 組織の変遷（体制・分掌・課題）

年代	名称	人員	分掌事項	課題
1990 年代～2010 年	MPI/CES/LMU・RRU 兼務体制	LMU 兼任 1 名	ラビュッテ地区崩壊対策による各種計測器観測	斜面災害対応の技術者いない
2009 年～2013 年	MPI/CES/LMU・RRU 兼務体制	兼任 6 名	災害スキーム載災害準備避難プロトコルの実施	この任に適する技術者がいない。コンサルタントがモニタリング対応。責任体制不明確
2013 年～2015 年	LMU (JET-C/P)	兼任 6 名	災害対応を自立的に行えるよう、地すべりの基礎知識技術移転し避難計画見直しと対応	地すべり対策を行う技術者・広報担当者が不足。組織の規定、規律が確立されていない。
2015 年	LMU 独立化	常任職員 7 名	NDRRMC の記載事項のうち Landslide に特化した国レベルのサポートを行う	LMU の兼任を解き単独組織化も LMU が CES 傘下の組織であるため CES の規定が適用される。災害対応時の LMU 業務実施体制、適切な人材登用について MPIHQ と協議も変化なし
2016 年～2017 年	LMU (JET-C/P)	常任職員 7 名→（兼任 7 名）	地すべりのみならず、他斜面災害種（落石、斜面崩壊、土石流）への対応能力強化、組織強化	LMU の各種要請に対する MPI Head Office の動きが遅く、LMU は中途半端な業務継続を行うのであれば、LMU を設計兼任とし、現在の優先順位として設計対応を主体とする旨、Head Office に通達

LMU メンバーが課題と考えている問題は以下のとおりである。

A)　LMU の活動を規定する就業規則や目的（マンデート）が不明確（規則の改定）

MPI-Head Office/CES/LMU メンバーが CES 規則によって採用される（されている）ことに起因する。例えば CES の就業規則 9 時~4 時までとなっているが、緊急災害時に NDRRMC の Landslide のプロトコルに従えば、場合によっては 24 時間対応を余儀なくされることがあるし、実際に NDRRMC より時間外での緊急な対応を行わざるを得なかったこともある。あくまでも MPI 内部の事情ではあるが CES の採用規定で採用された職員にとっては、今まで必要の無かった時間帯に勤務する必要性が生じ、時間外手当なども出ない、職務に見合った条件での作業からをせざるを得ないことへの不平・不満があった。

B)　斜面災害全般に対応するための基礎知識を持っていない技術者が JET からの技術移転をもって専門家とされるのは不適当（責任問題の回避）

モーリシャス国内には地質工学あるいは地盤工学を専門とする技術者がいないため、地質学を修めたプレム・サドル氏（64 才、現在中央水道公社総裁）を LMU に配属する方向で検討したものの、LMU 側から「地質的な素養があるものの、斜面災害に対処出来る能力を持っていない」との意見があり、却下された。JET は 2016 年 2 月、2 名の LMU 職員（地質工学技術者、広報担当者）を MPI に要請したが、1 年たった今でも採用されていない。特に地質工学技術者に関しては一般公募するための TOR を策定出来ない状況であり採用者不在のまま現在に至っている。また C/P（エンジニア）は Council of Engineers から土木工学エンジニアの資格を持っているものの、斜面災害や地質にかかる Specialization（該当分野に特化したタイトル-大学修士課程修了）を保有しておらず、モーリシャスの大学には該当する履修コースはない。

上記した問題や課題は、基本的にモーリシャスの制度、MPI の組織内部の問題に起因するものであるため、LMU は MPI Head Office に強く対処を求めてきた。また JET も早期解決に向けたミーティング、ワーキングセッションなどを開催し善処を促したものの、MPI の対処は非常に遅く、結果として当初から引きずっていた内的な問題が LMU 組織強化を進める上で障害となったまま推移した。

2）　モーリシャス政府内で斜面災害に対する課題

National Disaster Risk Reduction and Management Centre (NDRRMC) National Disaster Scheme (NDS)2015 年版には地すべりに対し MPI が緊急災害時に実施すべき内容が記載されている[1]7.1 条では地すべり多発地帯でのモニタリングが義務づけられている。また 7.7 条では緊急避難に伴う土塊移動値測定結果を NDRRMC に報告する義務を負う。NDS には「LMU」の記載は無いものの MPI には LMU 以外に地すべりを管轄する組織は存在しないので、必然

[1] P218, 7.0 LANDSLIDE EMERGENCY SCHEME National Disaster Risk Reduction and Management Centre (NDRRMC) National Disaster Scheme (NDS) 2016

的に対応組織は LMU となる。また NDRRMC は National Disaster Risk Reduction and Management Council の指示のもとに災害リスク削減につとめなければならない[2]。このように国家として災害管理を行う活動部隊が LMU であるという認識があるにも係わらず、LMU/MPI が適切な対応を取らないことは国家法令に反する懸念さえある。LMU のマンデートは国家災害計画の観点からも早急に確立すべきだと考えられるが、MPI 内部でいまだにこの問題が解決していないのは災害対応の管轄セクションとして矛盾するものである。

3)　組織強化策にかかる課題

C/P は個々の技術者がそれに適した資格を保有していないことが LMU 業務を行う上で最大の問題点であると認識している。そのためには以下の体制が不可欠である。

A)　組織として責任の明確化
B)　個別技術者の技能証明など認定されるための仕組み作り

C/P は個人的に JICA の取組に謝意を示しているものの、上位組織である MPI Head Office や管理者が責任と主体性を持ってとり組むべき課題が多数あると考えている。これらの点を解決すべくプロジェクト開始当初から改善要請を行ってきたことは前述した。しかしこれらの点を解決するためには、MPI 内部でも良く理解されていな「地盤工学、地質工学の専門家」が必要な要求事項について精査した上で決定されなければならない。具体的には次の表に示されている取組である。

表 7　LMU の課題と解決策（案）

	課　題	要求事項	対処方針
1	(斜面)災害対応組織としての責任の明確化	1) LMU 組織の責任範囲の明確化 2) LMU 組織の規程・規律を CES の重複無しに決定できる体制の構築 3) LMU が CES の傘下にあることによる規程・規律の煩雑化を防止	短期:LMU を PS の直下におく。当面は MPIPS もしくは地質技術者（見つかった場合）が直接責任権限で LMU を統括
2	責任組織として必要なリソースの同定と対応策の策定	1) 組織として斜面災害などに対応する時の個人の責任範囲の明確化 2) 独立した技術者に対する資格、条件の設定 3) 資格を与える側の審査機構の明確化と付与する機関の同定 4) 調査・モニタリングに必要な資機材にかかる検討と付与	短期：LMU 個別の規律・規程の策定と職員の責任範囲を明確化。技術基準・資格要件の提示

[2] The National Disaster Risk Reduction and Management Act (No.2 of 2016)

基本的には斜面災害にとどまらず、LMU は他の災害種を直接対応する実施主体者であることから、他災害種についても同様のコンセプトをもって対応が必要である。

５．２　　運営上の工夫

課題を踏まえつつ、運営上工夫した点は以下のとおりである。

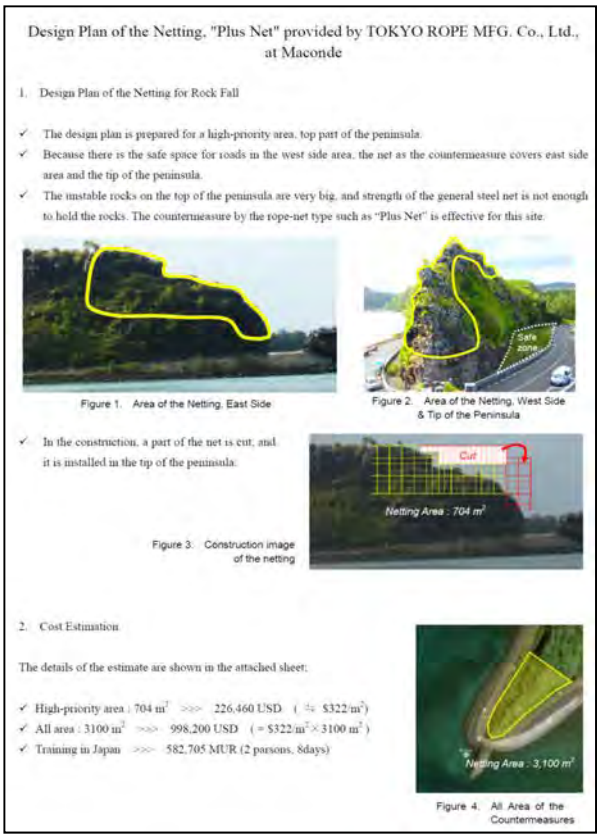
1）斜面災害全般の技術移転

C/P は前プロジェクトにおいて獲得した知識やノウハウを保有しているものの、MPI 組織内の問題から、モーリシャスにおいて公的に「地すべりの専門家」として認識される活動を拒否した。その主たる活動はセミナーでの技術移転成果等のプレゼンや新規斜面災害対策現場における調査や対応などである。従ってこれらの活動を避けつつも移転が円滑に行われるように工夫する必要があった。そのために次のような配慮をしつつ技術移転を進めた。

A) マニュアル策定にあたっては、日本のマニュアルを参照しつつ、現地にてマニュアルを応用しながら作業を進めた。MPI への他省庁からの各種斜面災害対応要請には、JET が調査を行うという名目のもとで現地調査、対策計画立案を OJT で実施した（具体例：バテラージ斜面崩壊の設計施工対策）。

B) 具体的な対策工設計依頼に対しては、日本国内のメーカーを MPI に紹介すると同時に対策工の具体的な検討を協働して実施することにより、より C/P が実践的な対策が行えるよう配慮した（具体例：マコンデの落石現場の対策に国内メーカーのロックネットの設計を行った）。

C) 他の関係機関との連携を重視し、C/P を巻き込んだ第三者機関への移転を積極的に実施した（具体例：落石調査を依頼する SMF（Special Mobile Force）に、落石調査方法、インベントリ作成方法を指導した。そのための落石調査マニュアルを作成した）。


Design Plan of the Netting, "Plus Net" provided by TOKYO ROPE MFG. Co., Ltd., at Maconde

1. Design Plan of the Netting for Rock Fall

- The design plan is prepared for a high-priority area, top part of the peninsula.
- Because there is the safe space for roads in the west side area, the net as the countermeasure covers east side area and the tip of the peninsula.
- The unstable rocks on the top of the peninsula are very big, and strength of the general steel net is not enough to hold the rocks. The countermeasure by the rope-net type such as "Plus Net" is effective for this site.

Figure 1. Area of the Netting, East Side

Figure 2. Area of the Netting, West Side & Tip of the Peninsula

- In the construction, a part of the net is cut, and it is installed in the tip of the peninsula.

Figure 3. Construction image of the netting

2. Cost Estimation

The details of the estimate are shown in the attached sheet;

- High-priority area : 704 m² >>> 226,460 USD (≒ $322/m²)
- All area : 3100 m² >>> 998,200 USD (= $322/m²×3100 m²)
- Training in Japan >>> 582,705 MUR (2 persons, 8days)

Figure 4. All Area of the Countermeasures

B)の事例（東京ロープによるロックネット）


C）の事例：SMF に対する落石調査の指導-C/P が積極的に関与した

上述した活動は、C/P にとっては LMU としての活動ではあるものの、JET との協働であるという名目で作業を進めることができ、かつ現地や対策工設計を行うにあたって主体的な活動を行う必要性があったため、必然的に技術移転が進むこととなった。

2）斜面災害に対する MPI アドミニスタッフへの啓蒙活動

本プロジェクトでは MPI 全体の斜面災害に対する認識不足が原因となっていることから、MPI 大臣、Permanent Secretary（PS）、Deputy PS（DPS）を含む MPI 本部関係者に対して「何故災害対応セクションが必要なのか」という根本的な問いに対する答えを一貫して説明した。一連の協議は 10 回以上行われた。その主な内容は以下のとおりである。

表 8　MPI 本部での組織体制にかかる主要協議

日程	参加者	議題	成果
20/12/2016	DPS	• LMU のマンデート検討 • 地質工学技術者、地質技術者の採用	• LMU が持つ課題に対する MPI 本部の理解向上
10/02/2017	DPS	• LMU の持続発展性とプロジェクト成果 • LMU もしくは新組織の最適な設立について	• LMU に適切な技術者が配属されていないこと対する MPI 本部の理解向上
14/02/2017	PS, CES 局長, PS 補佐官, 事務管理官	• LMU の現状にかかる MPI 本部との情報共有 • GEO の設立と関連法令の整備にかかる協議	• 技術移転を行う C/P が公的に存在していない事に対する JET の問題共有 • LMU の現状に対する MPI 本部の
27/02/2017	PS, DPS, PS 補佐官,事務管理官	• MPI 本部が策定したマンデートにかかる情報共有と組織改訂	• 新しい組織体制にかかる確認
09/03/2017	大臣,大臣顧問, PS, 2 DPSs, CES 局長	• LMU の課題や解決手法にかかる大臣との情報共有 • MPI の GEO 設立計画確認	• 新しい組織設立にかかる人材と方法にかかる確認 • 大臣による新組織設立の迅速化のサポート

10/03/2017	DPS, 補佐官	• 今でのプロジェクト状況説明, LMU's 現状、問題点、解決策	• 本プロジェクトと組織問題にかかる理解の向上
10/03/2017	大臣顧問	• GEO の開設準備と組織体制にかかる協議 • GEO が設立されるまでの LMU の役割	• GEO の組織体制の確認
16/03/2017	DPS	• GEO の組織体制、予算と人材確保	• GEO の組織体制の確認
22/08/2017	CES 局長、副局長	• LMU の現状､GEO 設立にかかる情報共有	• LMU の状況と GEO 設立にかかる MPI 本部の理解向上
28/08/2017	CES 技師	• 斜面災害管理にかかる最近の作業の情報共有	• CES 技術者の作業状況の確認
30/08/2017	DPS. CES 局長	• GEO 設立にかかる最近の動向にかかる情報共有	• GEO の現状にかかる MPI 本部の理解向上
07/12/2017	2 DPSs, CES 局長と 4 MPI 職員	• 人材採用手順にかかる情報共有 • GEO 局長の人材採用 TOR の最終化	• 新組織に必要な人材の同定と採用手順

これらの活動を通じて MPI でも最高責任者である MPI 大臣をはじめとする斜面災害対応に対する MPI の関与不足が明らかにされるとともに、その重要性が認識されたと判断している。

3）公共コミュニケーション活動

プロジェクト開始来懸案となっていた Public Communication Officer の不在により､これに関連する活動の技術移転の進捗が無かった。MPI の上層部との協議を通じ、当面は MPI 全体を統括する GIS に対応をしてもらい、その内容を将来雇用予定の人材に移転するよう依頼した。MPI より快諾され、斜面災害の理解を進めるためのパンフレットの改訂作業を進めた。その結果として、よりわかりやすいハンドブックが完成した。

図 4　斜面災害ハンドブック。よりシンプルでかつ英語、仏語、クレオール対応

５．３　　運営上の教訓（業務実施方法、運営体制）

前プロジェクトで行った技術移転の成果を踏まえ、より広範な災害種にも対応すべく進めたが、最終的に先方政府が斜面災害を管轄するセクションの重要性と必要性を認識させるまで多くの時間を費やした。LMU の組織強化にかかる課題は早期に解決するものであったが、MPI 内部でのコンフリクトが根深く、かつ技術移転に支障が出るほどのものであるとの認識が不足していた。本プロジェクトの教訓は下記のとおりである。

1） C/P 組織が抱える問題点の深掘りの必要性

技術移転プロジェクトにおいてそれを受け入れる組織と個々人の抱えている問題を十分に把握することの必要性を強く感じた。特に受入側の考え方は将来的にどのようになることがベストなのかを把握しないまま技術移転を続ければ、自律発展性や継続性が担保されない懸念がある。従来のスタンスは MPI が要請し受け入れたのだから、MPI 内のコンフリクトについては業務の範囲外ととらえてはならない。特に中高進国では個々の教育レベルは十分に高く、それぞれの思想が大きくプロジェクトの成否に関わってくる事を理解する必要がある

2） 代換え案のいち早い提示と方向転換

課題を把握した上で LMU のとるべき道筋を MPI の組織上の問題であると決めつけること無く、柔軟な発想で課題を克服するための選択肢を複数用意する必要がある。本プロジェクトの場合は、MPI の本部担当者が計 3 回も変わったことも LMU と本部の意思疎通に負の影響を与えたと同時に、LMU の上長である CES 局長への理解を十分に求める必要があった。CES 局長（当時）は、JICA の技術移転について「前プロジェクトのフォローアップ」と「LMU に求められる斜面災害対応のアドバイス」ととらえており、JICA が関与しない状況では LMU の作業を継続しないと発言している。この時点でスコープの変更を含む技術移転の効果的な対応策を検討すべきであった。新規組織を立ちあげるまでには人材や予算などのリソースがそれなりに求められる事から、相手の予算措置を講ずるなど早めに対応することが重要である。

3） 国の技術者登録制度の設置

モーリシャスには地盤工学にかかる教育機関は存在しないと同時に地盤工学分野での責任体制を規定した登録制度が存在していない。従って斜面対策設計に対して、その対策が妥当かどうかの判断を行うことが出来ない。このようなシステムを改善し、必要要件を満たす技術者の登録制度を見直すなどの方法を検討すべきである。

５．４　　今後の課題

MPI はプロジェクトの終盤でようやく地盤工学の専門知識の必要性を認識した。このプロジェクトの斜面災害対応にとどまらず、広く地盤工学の知識を持ったプロ集団の育成を真剣に考えている。

MPI との協議を通じ、以下の点が明確となった。

- LMU に代わる新組織を Geotechnical Engineering Office（GEO=仮称。Geotechnical Engineering Unit など呼称は未定）とし、今後約 2 年間かけて設立を目指す。
- GEO はある程度の権限が認められる Autonomous Institution とし、GEO 内に地すべりを管轄する部署とそれ以外の地盤工学関連を管轄する部署 2 つを設立する。
- GEO 設立計画を具体化し、人材確保等を進める。
- GEO には、JICA 既往プロジェクトにおいて技術移転を受けた技術者も配属する。
- 組織の課題として LMU のマンデートがないことが挙げられおり、マンデート作成し議会に提出・承認を得る予定だったが、GEO 設立が明確となったため、LMU のマンデートは作成せず、GEO の組織設立計画（予算編成、人材確保、活動準備等）を進める。

これらの対処方針は 1)組織の配置、2)組織の責任体制の明確化、3)責任体制を堅持するためのツールについて具体的な提言を行い、すみやかな実施体制の基礎を確立することである。以下、GEO の組織計画案と LMU の MPI 内のポジション（案）を示した。LMU メンバーは従来のままで、ここでは MPI/PS 直下組織として CES の規律・規程に縛られることなく活動出来る案であると考える。

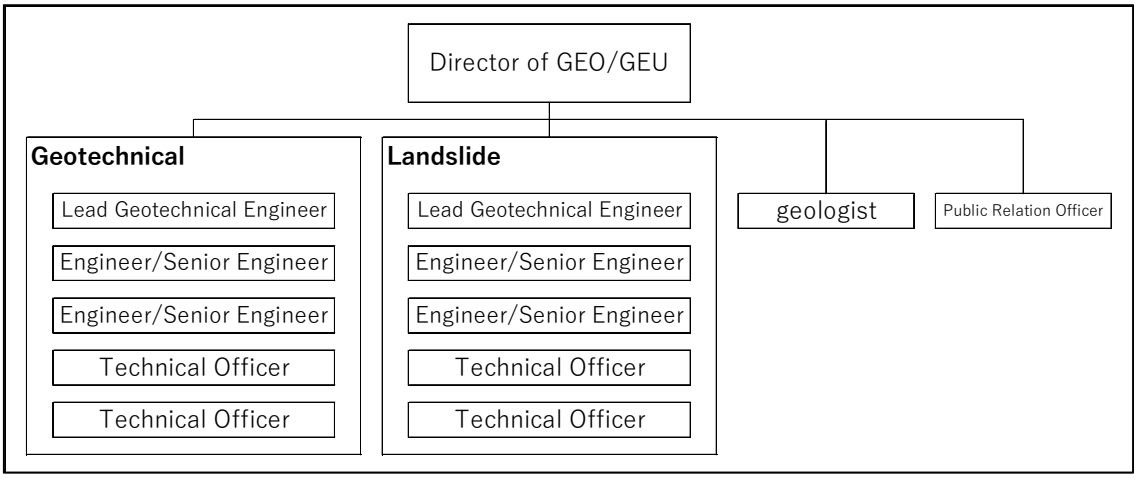


図 5　GEO の組織計画

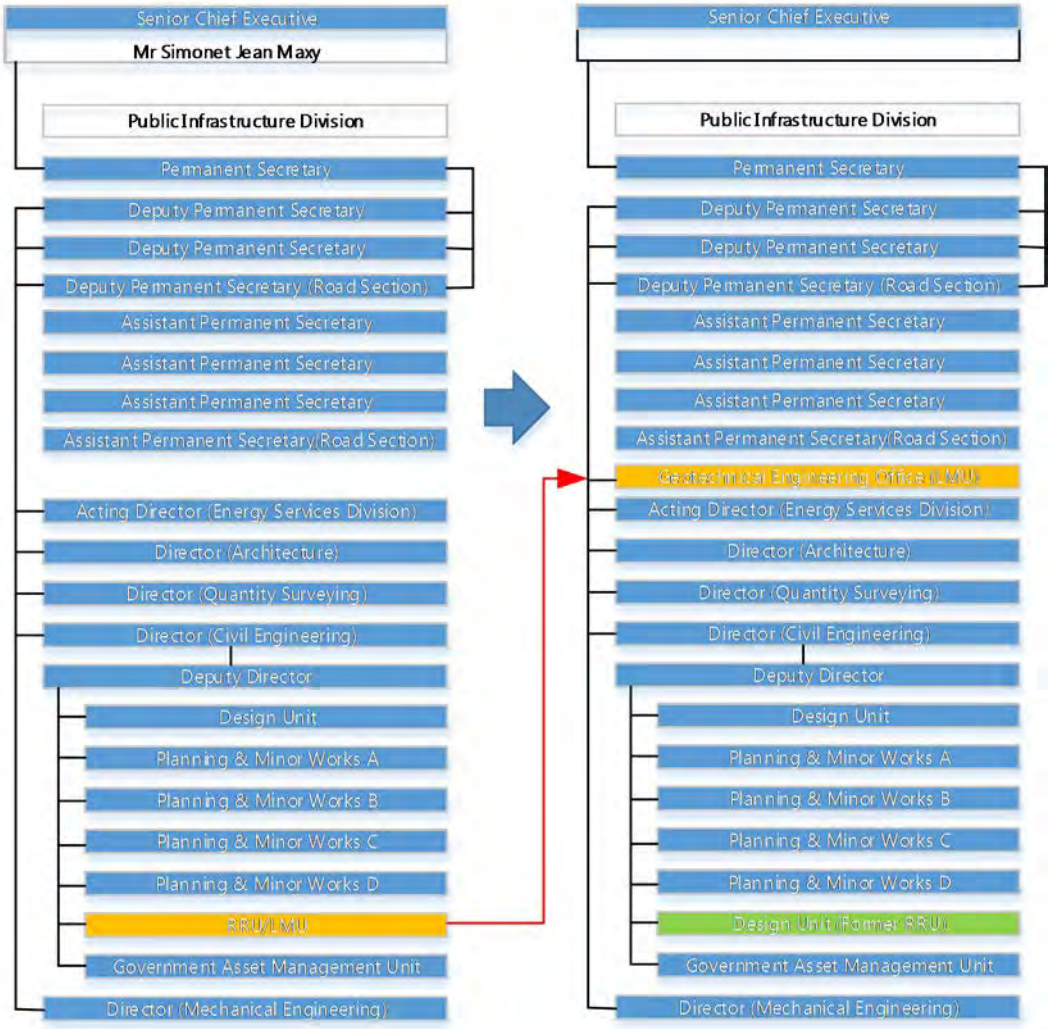
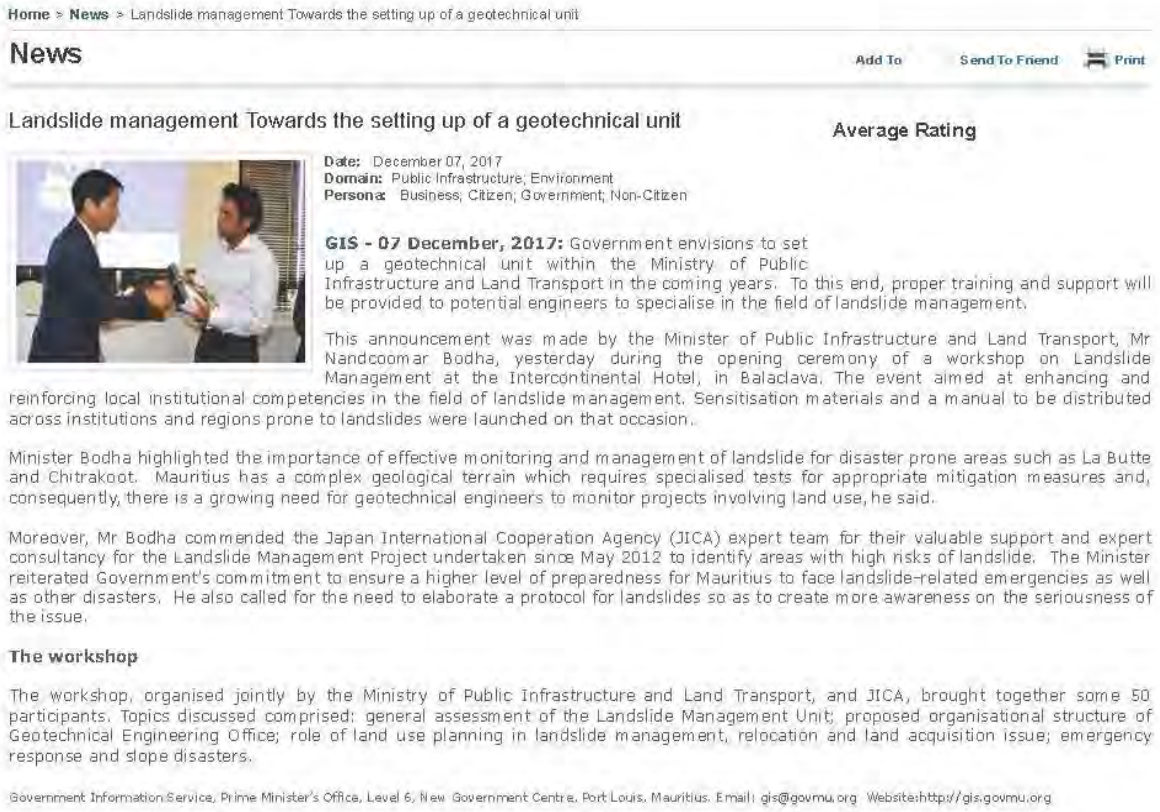


図 6　GEO の MPI 内での位置付け

これらの活動をとりまとめると以下のとおりである。

- LMU の Mandate や Registered Engineer としての取扱で健在化したため、組織体そのものの抜本的な見直しを行った。
- 組織強化対象として従来の LMU に対してそのまま実施した。現地調査業務にてマニュアル内容の解説を行った。
- GEO には技術移転した LMU のメンバーが入ることとなり、移転技術の継続性は確保された。
- GEO の設立によって上述の課題を払拭することとなった。GEO の設立について大臣が公言（TV）し実質的な作業に入った（組織・人員の TOR 作成）



Home > News > Landslide management Towards the setting up of a geotechnical unit

News

Add To　Send To Friend　Print

Landslide management Towards the setting up of a geotechnical unit

Average Rating

Date: December 07, 2017
Domain: Public Infrastructure; Environment
Persona: Business; Citizen; Government; Non-Citizen

GIS - 07 December, 2017: Government envisions to set up a geotechnical unit within the Ministry of Public Infrastructure and Land Transport in the coming years. To this end, proper training and support will be provided to potential engineers to specialise in the field of landslide management.

This announcement was made by the Minister of Public Infrastructure and Land Transport, Mr Nandcoomar Bodha, yesterday during the opening ceremony of a workshop on Landslide Management at the Intercontinental Hotel, in Balaclava. The event aimed at enhancing and reinforcing local institutional competencies in the field of landslide management. Sensitisation materials and a manual to be distributed across institutions and regions prone to landslides were launched on that occasion.

Minister Bodha highlighted the importance of effective monitoring and management of landslide for disaster prone areas such as La Butte and Chitrakoot. Mauritius has a complex geological terrain which requires specialised tests for appropriate mitigation measures and, consequently, there is a growing need for geotechnical engineers to monitor projects involving land use, he said.

Moreover, Mr Bodha commended the Japan International Cooperation Agency (JICA) expert team for their valuable support and expert consultancy for the Landslide Management Project undertaken since May 2012 to identify areas with high risks of landslide. The Minister reiterated Government's commitment to ensure a higher level of preparedness for Mauritius to face landslide-related emergencies as well as other disasters. He also called for the need to elaborate a protocol for landslides so as to create more awareness on the seriousness of the issue.

The workshop

The workshop, organised jointly by the Ministry of Public Infrastructure and Land Transport, and JICA, brought together some 50 participants. Topics discussed comprised: general assessment of the Landslide Management Unit; proposed organisational structure of Geotechnical Engineering Office; role of land use planning in landslide management, relocation and land acquisition issue; emergency response and slope disasters.

Government Information Service, Prime Minister's Office, Level 6, New Government Centre, Port Louis, Mauritius. Email: gis@govmu.org Website:http://gis.govmu.org

図 7　MPI の HP、プレスリリースで正式発表された Geotechnical Unit の設立

モーリシャスの課題として以下の点をあげる。

- 組織体制確立：LMU での失敗を教訓として、新組織には斜面災害対応のための規定、組織体制を立案することが不可欠である。また、これを進めるためには経験のある地盤工学分野の専門家がリードする必要がある。まずはこの人材を確保することが当面の課題であると思われる。

- 人材育成・発掘： ABE イニシアチブスキム（地盤工学）で LMU から日本に派遣されているデビチャラン氏への期待が高まっている。2018 年 3 月にモーリシャスに帰国予定ではあるが、彼のような人材を有効に活用するための環境がない。当面は上述したとおり経験のある地盤工学の専門家が新たな体制とリソースを整備するとともにデビチャラン氏に経験を積ませる必要がある。このようなベースとなる活動は 2018 年度国費留学生ゴビン氏が帰国するまでの間（2020 年）になされる必要がある。

- 新組織の将来展開：MPI は GEO を将来アフリカ・インド洋地域を対象とした国際協力センターのコアとして発展させたいと考えている（アフリカ・インド洋地盤工学センター構想）。モーリシャスは現在「アフリカのシンガポール」を目指しており周辺地域

への金融センターのみならず、国内外のインフラ整備にかかる技術面のサポート強化を進めている。そのためには各分野にコアとなる人材整備が必要であり、様々な援助組織から協力を引き出している。

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF PUBLIC INFRASTRUCTURE AND LAND TRANSPORT (MPI)

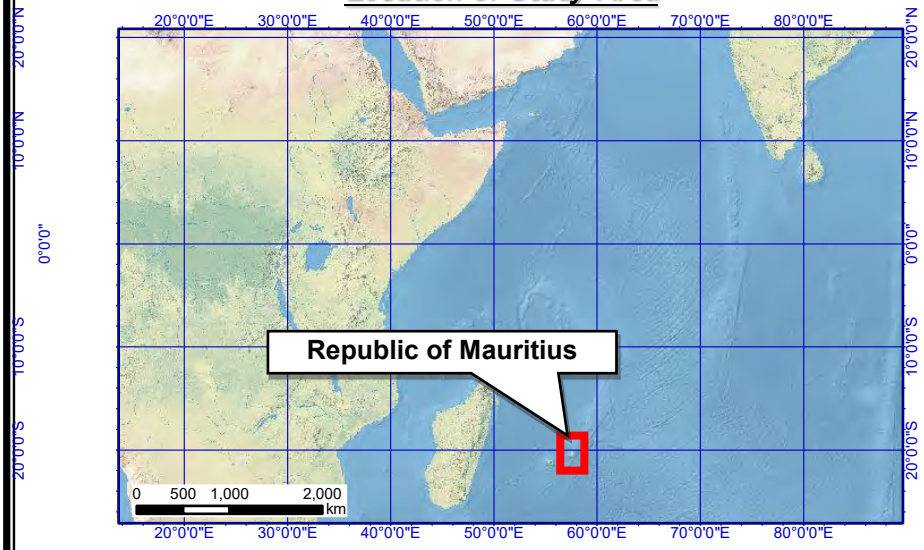
TECHNICAL COOPERATION PROJECT:
LANDSLIDE ADVISER FOR MAURITIUS

APPENDIX

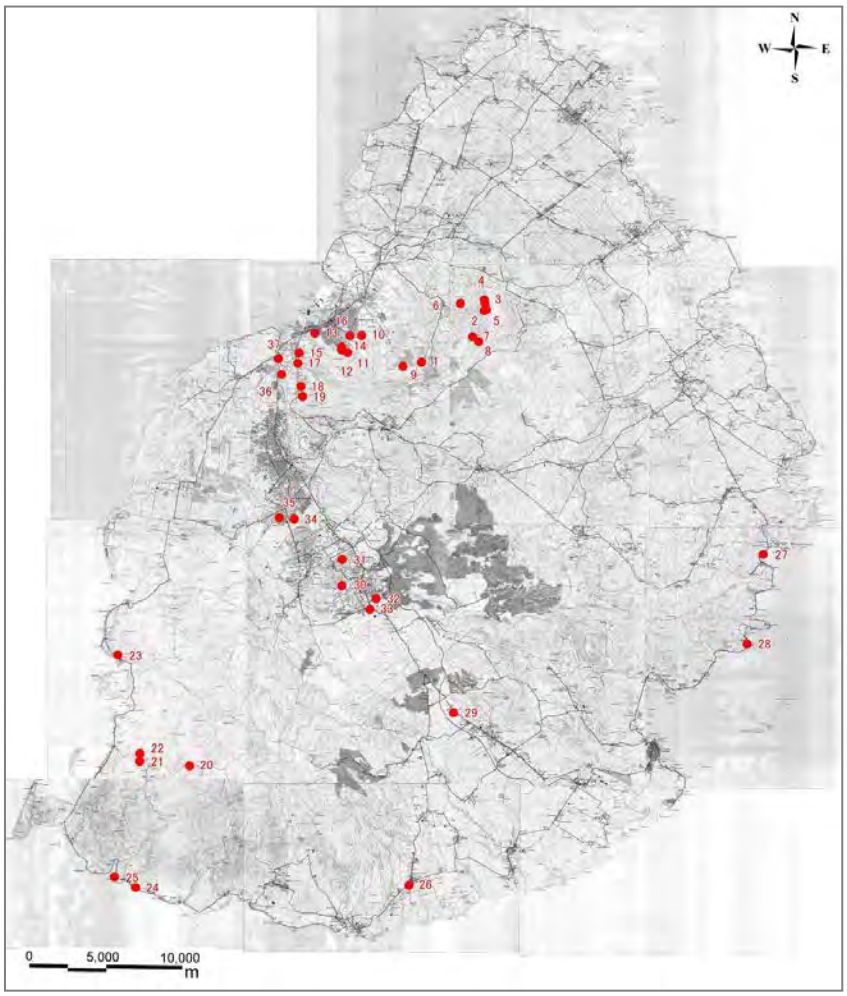
FEBRUARY 2018

KOKUSAI KOGYO CO., LTD.

Location of Study Area



Detail Map



Rate of Currency Translation

1 USD = 32.1306 MUR
= 110.69 JPY

100 MUR = 2.95035 USD
= 326.57 JPY

MUR: Mauritius Rupee

As of 17 January 2018

Photos of the Project Activities (1) January 2016 – December 2017

【Landslide sites】

Landslide countermeasure constructed under the Previous JICA Project, Chitrakoot

Landslide countermeasure constructed under the Previous JICA Project, Chitrakoot

Measuring at the horizontal drainage constructed under the Previous Project, Chitrakoot

Automatic Weather Station (AWS) for early warning installed by the Mauritius Meteorological Services (MMS), Chitrakoot

Early warning system, Vallée Pitot

Early warning system, Vallée Pitot

Extensometer maintained by MPI/LMU, Vallée Pitot

【Slope failure sites】

The slope in which a retaining wall (1.5 m high) is to be applied, Batelage

The slope at middle of the road in which a crib wall is to be applied, Batelage

Site study of slope failure and rockfall, Hermitage

The investigation spot where two houses sit near the scarp, Camp Garreau, Flacq

Current condition of the site with slope failure and river erosion, Kewal Nagar Belle Rive

Cut slope failure, Pilot Bel Air

Construction of retaining wall at a place of possible slope failures, Batelage

Completed countermeasure work, Batelage

【Rock fall sites】

Rock fall, Maconde

Unstable rocks, Signal Mountain

Specification of unstable rocks, evaluation, and numbering, Signal Mountain

Marking the rocks, Signal Mountain

Consideration of measures (blue spray: stabilisation), Ruisseau Des Creoles

Unstable boulders on the steep slope, Coromandel

【Debris flow sites】

Countermeasure work for debris flow, Baie du Cap

【Meetings】

Kick-off workshop, Bagatelle, 10 February 2016

Minister's speech at the kick-off workshop, Bagatelle, 10 February 2016

Technical meeting on slope failures, rock falls and debris flows, Phoenix, 03 March 2016

Participants of Working session, Port Louis, 13 June 2016

Opening speech by the Minister in Working session, Port Louis, 13 June 2016

Technical meeting on slope failures, rock falls and debris flows, Phoenix, 14 July 2016

Technical meeting on rock falls, Phoenix, 20 July 2016

First Stakeholder meeting for implementation of the Work Section II, Chitrakoot, 17 August 2016

Second Stakeholder meeting for implementation of the Work Section II, Chitrakoot, 26 October 2016

Technical training for freshers, Phoenix, 22 May 2017

Technical training for freshers, Phoenix, 22 May 2017

Participants of seminar, Pointe Aux Piments, 01 March 2017

Presentation by the LMU engineer in the seminar, Pointe Aux Piments, 01 March 2017

Stakeholder meeting for phase 2 project of countermeasure works, Chitrakoot, 17 August 2016

Stakeholder meeting for phase 2 project of countermeasure works, Chitrakoot, 27 September 2016

Technical transfer workshop, Phoenix, 4 October 2017

Participants of the workshop, Balacrava, 6 December 2017

Handing over of the education materials in the workshop, Balacrava, 6 December 2017

CONTENTS

Appendix

3.1.1 Confirmation of the current situation of the landslide countermeasures in Chitrakoot Phase 1

3.1.2 Stakeholder meeting for the implementation of Phase 2 at Chitrakoot

3.1.3 MM of site meeting in Chitrakoot

3.1.4 Technical advice for supervision (1)

3.1.5 Technical advice for supervision (2)

3.1.6 Technical advice for supervision (3)

3.1.7 Confirmation of the current situation of the landslide countermeasures in Chitrakoot Phase 2

3.1.8 Site inspection for the maintenance of the countermeasure in Chitrakoot

3.1.9 Procedure of the maintenance

3.1.10 Technical meeting for procedure manual of the maintenance of landslide countermeasures

3.1.11 Technical workshop for evaluation of the effects of the countermeasure work

3.1.12 Evaluation method for effects of the landslide countermeasure by using stability analysis

3.1.13 Work plan for evaluation of the countermeasure

3.1.14 Landslide investigation by MPI in Vallee Pitot

3.1.15 DD of the countermeasure

3.1.16 Construction of landslide countermeasures in Vallee Pitot

3.2.1 Explanation of slope failures, rock falls and debris flows

3.2.2 Slope inventory

3.2.3 Slope inspection sheet

3.2.4 Effects of the constructed countermeasure works (evaluations)

3.2.5 Procedure for elaborating a slope map in QGIS

3.2.6 Usage of Manual

3.2.7 Support for preparing the materials for inspection, countermeasures and public awareness materials by MPI

3.3.1 Current monitoring system

3.3.2 Proposed remote monitoring system

3.4.1 Early warning evacuation system in Chitrakoot & Vallee Pitot

3.4.2 Simple setting manual for EWS

3.4.3 Automatic rainfall monitoring system (AWS of MMS)

3.5.1 Questionnaire survey results

3.5.2 Sensitisation materials

3.5.3 Distribution plan of sensitisation materials

3.6.1 Memorandum issued by MPI

3.6.2 Programmes and attendance lists for kick-off workshop, working session, seminar and workshop/seminar

3.6.3 Media coverage for workshop/seminar

List of Tables

List of Figures

List of Photos

Abbreviations

Abbreviation	English
AWS	Automatic Weather Station
C/P	Counterpart
CES	Civil Engineering Section
CCPL	City Council of Port Louis
CES	Civil Engineering Section
CS	Cut Slope for Road
DD	Detail Design
DEM	Digital Elevation Model
Dep	Depression
DF	Debris Flow
DG	Director General
DPS	Deputy Permanent Secretary
DV	Development
EWS	Early Warning System
FL	Filling for Road
GEO	Geotechnical Engineering Office
GIS	Geographic Information System
GIS	Government Information Service
GSM	Global System for Mobile Communication
ICTA	Information and Communications Technologies Authority
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
LMU	Landslide Management Unit
MFRS	Mauritius Fire and Rescue Services
MHL	Ministry of Housing and Lands
MMS	Mauritius Meteorological Services
MSSNSESD	Ministry of Social Security, National Solidarity, and Environment and Sustainable Development (former Ministry of Environment, Sustainable Development, Disaster and Beach Management (MOESDDBM))
MPI	Ministry of Public Infrastructure and Land Transport
MPI HO	MPI Head Office
NDRRMC	National Disaster Risk Reduction and Management Centre
OJT	On the Job Training
PPG	Planning Policy Guidance
PRB	Pay Research Bureau
PS	Permanent Secretary
RDA	Road Development Authority
RE	River Bank Erosion
RF	Rock fall
SF	Slope Failure
SMF	Special Mobile Force
SMS	Short Message Service

Chapter 1

Introduction

1 Introduction

1.1 General

Japan International Cooperation Agency (hereinafter JICA) has implemented the 'project of landslide management in Mauritius' (hereinafter the Previous Project) from May 2012 to July 2015 as a part of climate change adaptation and disaster mitigation programme for Small Island Developing States. This project of Landslide Adviser for Mauritius (hereinafter the Project) is planned to be implemented as a successor project of the Previous Project. Therefore, the Project has to be carried out identifying its role as being a part of the programmes against climate change. This Progress Report covers the activities and outcomes of the Project from January 2016 to March 2018.

1.2 Objectives and Outcomes of the Project

The outline of the Project is as shown in Table 1.2.1 below.

Table 1.2.1 Outline of the Project (Source: JET)

Items	Contents and details
Name of the Project	Landslide Adviser for Mauritius
The Project period	From January 2016 to March 2018 (approximately 26 months)
Overall goal	To mitigate slope disasters in Mauritius
Expected outcomes	1. Technical transfer on landslide countermeasures' management and maintenance implemented in the Previous Project by JICA from May 2012 to July 2015 is continuously carried out, firmly establishing these technologies. 2. The advanced technologies in implementing 'surveys, analyses, designs, construction supervision, and management and maintenance' of slope disaster countermeasures including slope failures, rock falls and debris flows are transferred.
Activities	1. Technical support for implementation of the project evaluations and management and maintenance of landslide countermeasures 2. Technical support for implementation of the surveys, analyses, designs, construction supervision, management and maintenance, and project evaluations of slope failure, rockfall and debris flow countermeasures 3. Technical support for establishment of the remote monitoring system for slope disasters 4. Technical support for updating the early warning/evacuation system based on the results of the countermeasures against slope failures, rock falls and debris flows 5. Technical support for updating the land use regulation in the Planning Policy Guidance (PPG) based on the results of the countermeasures against slope failures, rock falls and debris flows 6. Technical support for development of the institution, system, and capacity of the Landslide Management Unit (LMU)
Counterpart (C/P) organisation	LMU, Ministry of Public Infrastructure and Land Transport (MPI)

1.3 Project work flow

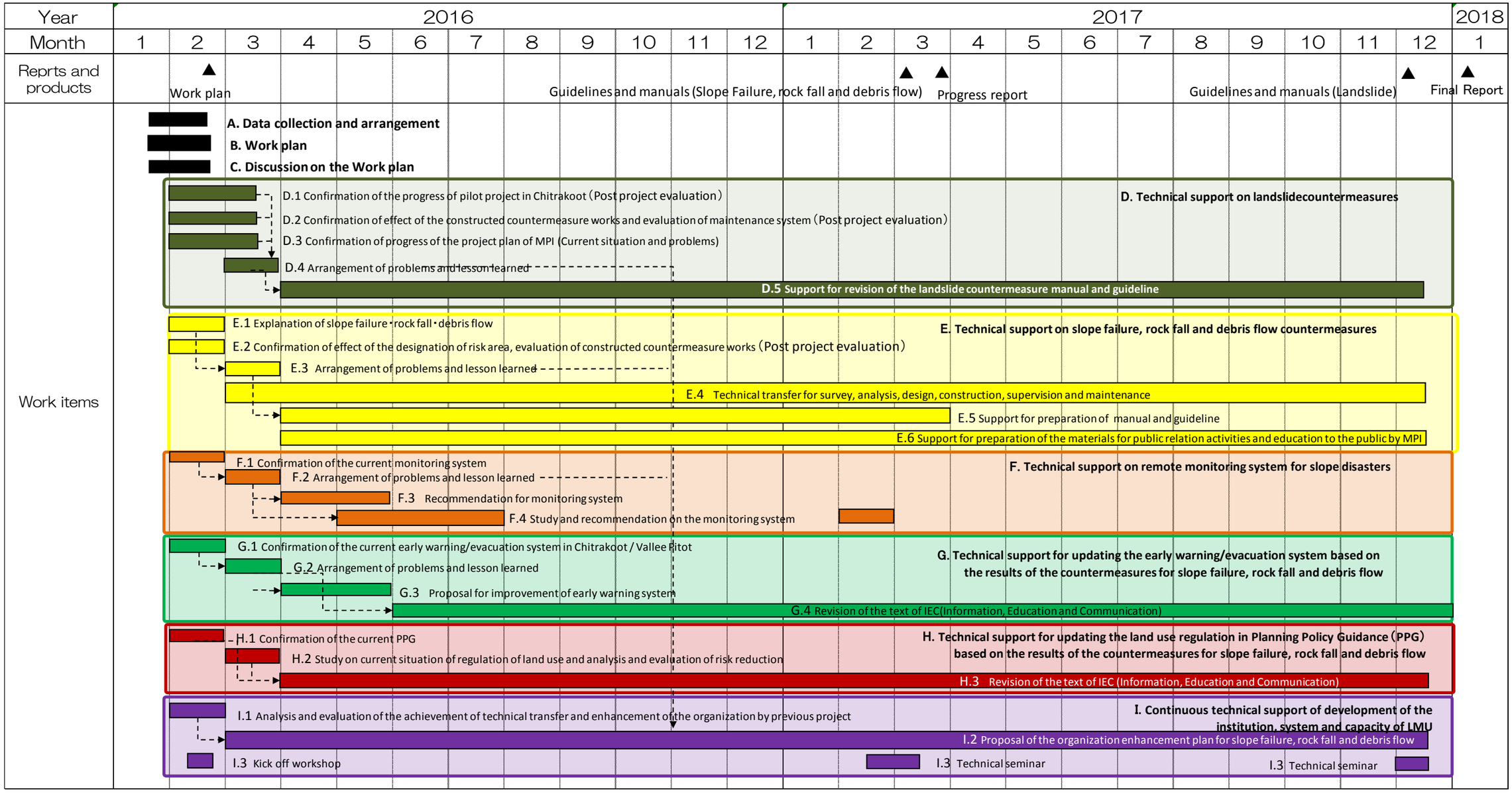


Figure 1.3.1 Project work flow (Source: JET)

Chapter 2

Project output

2 Project Output

2.1 Summary of Status by Output

The status of the Project outputs is summarised in the following table.

Table 2.1.1 Project outputs and its final status (Source: JET)

Output	Action	Final Status and Reference
Technical support on landslide countermeasures	Confirmation of the progress of pilot project in Chitrakoot	The work will be continued until end of January 2018.
	Confirmation of the effects of the constructed countermeasure works and evaluation of the maintenance system	Effects of phase 1 countermeasure under the Previous Project has been evaluated.
	Confirmation of the progress of the project plan of Ministry of Public Infrastructure and Land Transport (MPI) (current situation and problems)	Compiled in this report
	Identification of problems and lessons to be learned	Design work was properly prepared, and the site management work was conducted by Landslide Management Unit (LMU)
	Support for revision of the landslide countermeasure manual prepared by the Previous Project	Compiled in the Manual
Technical support on slope failures, rock falls, debris flow countermeasures	Explanation of slope failures, rock falls and debris flows	Completed through seminars and site survey
	Evaluation of the effects of the constructed countermeasure works, and designation of risk areas	Evaluation work was conducted together with C/P
	Problems identified and lessons to be learned on slope failures, rock falls and debris flow countermeasures	Compiled in the Manual
	Technical transfer in implementing surveys, analyses, designs, construction supervision, and management and maintenance for slope failures, rock falls and debris flows	Seminars and on-the-job training at sites are conducted
	Support for formulating the manual of slope failures, rock falls and debris flows	Compiled in the Manuals
	Support for preparing the materials for public relation and public awareness activities by MPI	Compiled in the 'Landslide Disaster Prevention Handbook'
Technical support for establishing a remote monitoring system for slope disasters	Confirmation of the current monitoring system	Checked and revised
	Problems identified and lessons to be learned	Compiled in this report
	Recommendations for monitoring system	Compiled in this report
	Study and recommendations on the monitoring system	Compiled in this report
Technical support for updating the early warning/ evacuation system based on the results of the countermeasures for slope failures, rock falls and debris flows	Confirmation of the current early warning/evacuation system in Chitrakoot and Vallée Pitot	Confirmed. No specific issue raised
	Problems identified and lessons to be learned	Compiled in this report
	Proposal for the improvement of early warning system	Compiled in this report
	Revision of the awareness and sensitisation materials	Compiled in this report
Technical support for updating the	Confirmation of the current Planning Policy Guidance (PPG)	PPG 9 came into effect in March 2016

land use regulation in the PPG based on the results of the countermeasures for slope failures, rock falls and debris flows	Analyses and evaluations of the effects of risk reduction, and study on the status of the land use regulations	Compiled in this report
	Proposal for the revision of the PPG for slope failures, rock falls and debris flows	Revision was not made. However, the recommendations were made to MHL to refer to the Manuals for new development of the area.
Technical support for continuous development of the institution, system, and capacity of the LMU/MPI (confirmation of the proposal in the Previous Project and additional technical support for its implementation)	Analyses and evaluations of the achievements of technical transfer, and enhancement of the organisation by the Previous Project	New organisation (Geotechnical Engineering Office (GEO)) is considered for enhancement of the capacity. LMU is to support GEO's activities
	Proposal of the organisation enhancement plan for slope failures, rock falls and debris flows	Initial Plan for setting up GEO is formulated. Compiled in this report
	Workshop/Seminars and Working session	Major activities: Kick-off workshop (February 2016), Working Session (June 2016), Seminar (March 2017) and Workshop/Seminar (December 2017). Compiled in this report.

Chapter 3

Project activities

Project Activities

3.1 Technical support on landslide countermeasures

3.1.1 Progress of pilot project in Chitrakoot

In the Previous Project, the pilot project area of Chitrakoot was set as the object for countermeasure. Given that this site is a residential area located in private land, it was expected that the time for land acquisition was going to take a long time, consequently it was decided that the countermeasure works would be divided into two work sections, Work Section I and II. The construction of Section I is called 'Phase 1', and the construction of Section II is called 'Phase 2'.

Phase 1 had been conducted during the previous project, 2014, and Phase 2 is conducted by the Ministry of Public Infrastructure and Land Transport (MPI) from 20 July and expected to be finished in the middle of February 2018. The locations of the two Work Sections are shown in the map below.

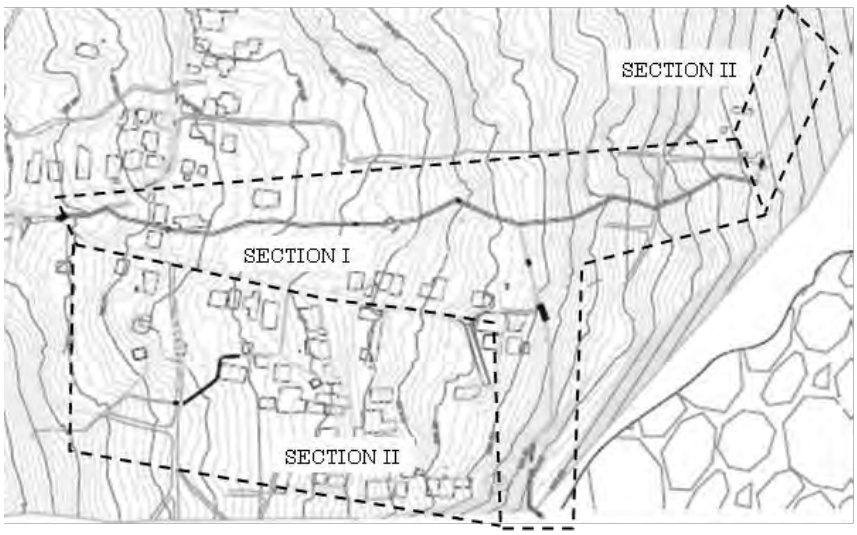
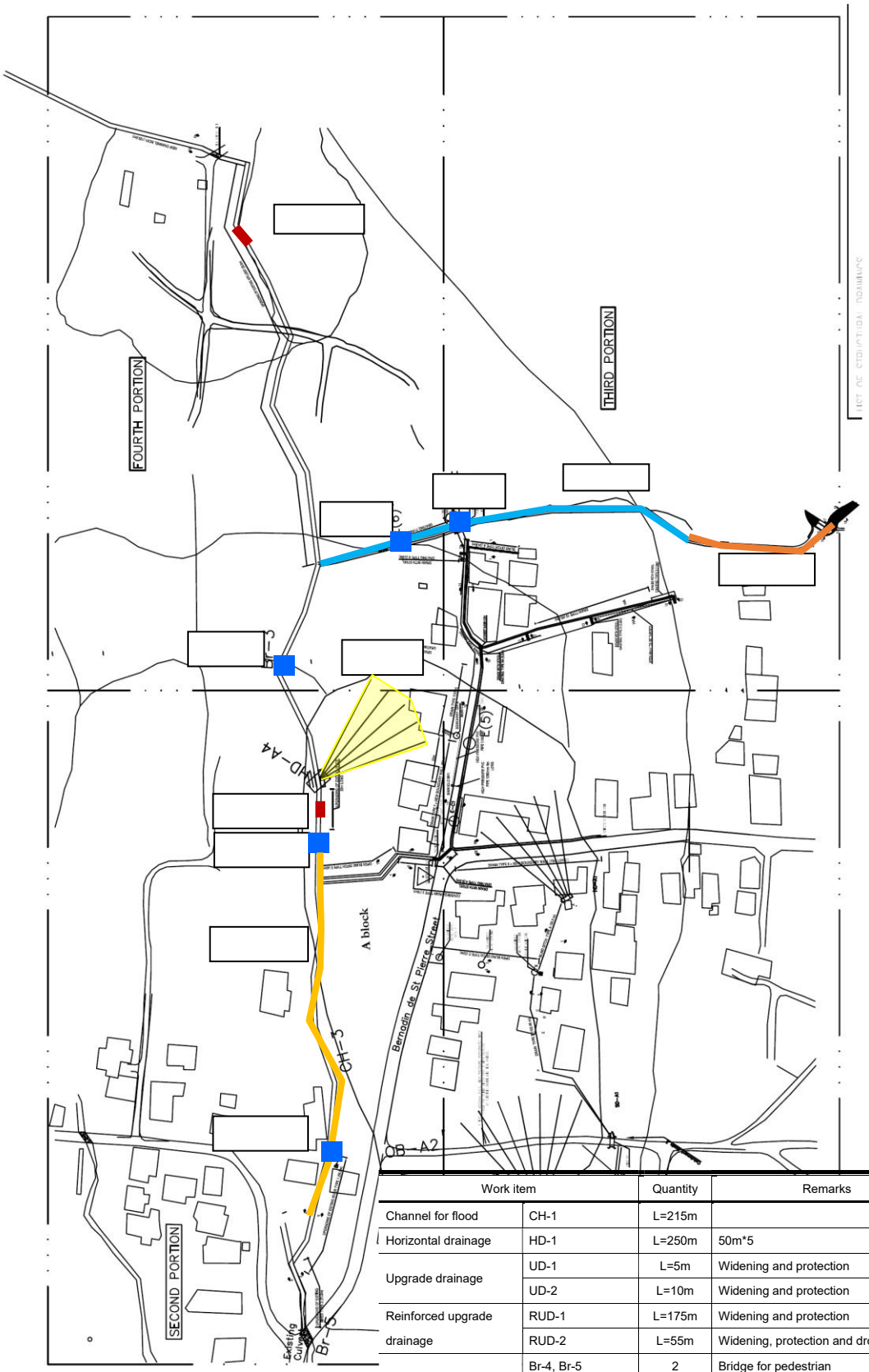
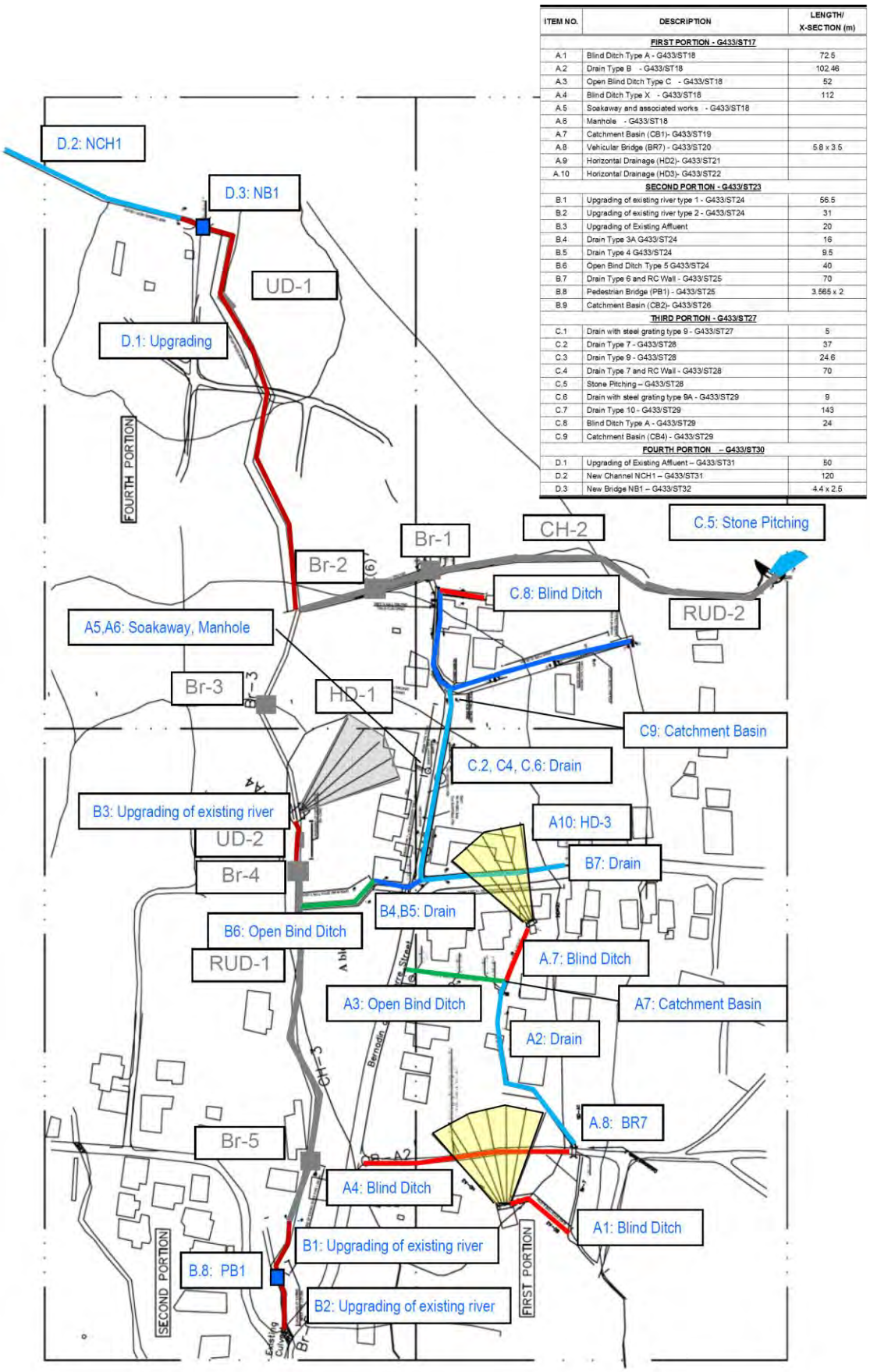


Figure 3.1.1 Work section of Block-A landslide in Chtrakoot (Source: The Project of Landslide Management in the Republic of Mauritius (Final Report), JICA, 2014)



Work item		Quantity	Remarks
Channel for flood	CH-1	L=215m	
Horizontal drainage	HD-1	L=250m	50m*5
Upgrade drainage	UD-1	L=5m	Widening and protection
	UD-2	L=10m	Widening and protection
Reinforced upgrade drainage	RUD-1	L=175m	Widening and protection
	RUD-2	L=55m	Widening, protection and drop structure
Ancillary work (Bridge)	Br-4, Br-5	2	Bridge for pedestrian
	Br-1, Br-2, Br-3	5	Bridge for vehicle

Figure 3.1.2 Location map of the countermeasure for Phase 1 in Chitrakoot (Source: JET)



ITEM NO.	DESCRIPTION	LENGTH/ X-SECTION (m)
	FIRST PORTION - G433/ST17	
A.1	Blind Ditch Type A - G433/ST18	72.6
A.2	Drain Type B - G433/ST18	102.46
A.3	Open Blind Ditch Type C - G433/ST18	52
A.4	Blind Ditch Type X - G433/ST18	112
A.5	Soakaway and associated works - G433/ST18	
A.6	Manhole - G433/ST18	
A.7	Catchment Basin (CB1)- G433/ST19	
A.8	Vehicular Bridge (BR7) - G433/ST20	5.8 x 3.5
A.9	Horizontal Drainage (HD2)- G433/ST21	
A.10	Horizontal Drainage (HD3)- G433/ST22	
	SECOND PORTION - G433/ST23	
B.1	Upgrading of existing river type 1 - G433/ST24	56.5
B.2	Upgrading of existing river type 2 - G433/ST24	31
B.3	Upgrading of Existing Affluent	20
B.4	Drain Type 3A G433/ST24	16
B.5	Drain Type 4 G433/ST24	9.5
B.6	Open Bind Ditch Type 5 G433/ST24	40
B.7	Drain Type 6 and RC Wall - G433/ST25	70
B.8	Pedestrian Bridge (PB1) - G433/ST25	3.565 x 2
B.9	Catchment Basin (CB2)- G433/ST26	
	THIRD PORTION - G433/ST27	
C.1	Drain with steel grating type 9 - G433/ST27	5
C.2	Drain Type 7 - G433/ST28	37
C.3	Drain Type 9 - G433/ST28	24.6
C.4	Drain Type 7 and RC Wall - G433/ST28	70
C.5	Stone Pitching – G433/ST28	
C.6	Drain with steel grating type 9A - G433/ST29	9
C.7	Drain Type 10 - G433/ST29	143
C.8	Blind Ditch Type A - G433/ST29	24
C.9	Catchment Basin (CB4) - G433/ST29	
	FOURTH PORTION – G433/ST30	
D.1	Upgrading of Existing Affluent – G433/ST31	50
D.2	New Channel NCH1 – G433/ST31	120
D.3	New Bridge NB1 – G433/ST32	4.4 x 2.5

Figure 3.1.3 Location map of the countermeasure for Phase 2 in Chitrakoot (Source: JET)

- MPI/LMU and JICA Expert Team (JET) visited the site and confirmed the current situation of the landslide countermeasures for Phase 1 and Phase 2.

- Through the construction period, MPI, with assistance of JICA expert, supervised the construction of the landslide countermeasures. And some technical advice was given by JICA expert as part of this supervision.

The contents and output of the activity for progress of pilot project in Chitrakoot are shown in the table below.

Table 3.1.1 Contents and output of the activity, progress of pilot project in Chitrakoot (Source: JET)

Date	Item	Contents	Organisation (the number of participants)	MPI/LMU	Reference /Output
08 March 2017	Site survey for Phase 1 in Chitrakoot	• MPI/LMU and JET have confirmed the current situation of the landslide countermeasures in Chitrakoot: Phase 1	MPI (2)	• Understanding of the present status • Practical use of manual, Procedure Manual for Landslide • On the Job Training (OJT)	Appendix 3.1.1
17 August 2016	Stakeholder meeting for Phase 2 at Chitrakoot	• Explaining the importance of the countermeasure works of Phase 2. • Obtaining the consent of the inhabitants to construct the countermeasure works on their plots of land.	MPI (3), National Disaster Risk Reduction and Management Centre (NDRRMC) (1), Ministry of Housing and Lands (MHL) (1), Other Authority (4), Local Authority (1), Inhabitant (25)	• Understanding of sensitisation activity procedure • Effective method of information dissemination	Appendix 3.1.2
26 October 2016		• Explaining the final planning of the project and its urgencies to the Inhabitants	MPI (3), NDRRMC (1), MHL (1), Local Authority (1), Inhabitant (8)		
17 August 2017		• Phase 2 of the countermeasure works (purpose, implementation period, details of the works) • Q & A session	MPI Head Office (HO) (2), LMU/MPI (7), related stakeholders (7), inhabitant (12)		
06 July 2017	1st Site meeting	• Site meeting for countermeasure in Chitrakoot • Assess overall progress of landslide countermeasure work on site and follow up on outstanding issues (was organized by MPI)	MPI (10), MHL (2), NDRRMC (1), Local Authority (1), Contractor (4), Others (7)	• Supervision of construction • Practical use of manual, Procedure Manual for Landslide • OJT	Appendix 3.1.3
07 September 2017	2nd Site meeting		MPI (6), Contractor (2)		
28 September 2017	3rd Site meeting		MPI (6), Contractor (6)		
26 October 2017	4th Site meeting		MPI (4), Contractor (4)		
07 December 2017	5th Site meeting		MPI (6), Contractor (5)		
20 September 2017	Technical advice for supervision (1)	• Through the construction period, some technical advice was given by JICA expert for supervision of the countermeasure construction.	MPI (4), Other (3)	• Supervision of construction • Technical Transfer for supervision of the countermeasure construction • OJT	Appendix. 3.1.4
27 September 2017	Technical advice for supervision (2)		MPI (6), Other (11)		Appendix. 3.1.5
07 December 2017	Technical advice for supervision (3)		MPI (2)		Appendix. 3.1.6
15 December 2017	Site survey for Phase 2 in Chitrakoot	• Confirmation of the current situation of the landslide countermeasures in Chitrakoot: Phase 2	MPI (2)	• Understanding of the present status • Practical use of manual, Procedure Manual for Landslide • OJT	Appendix. 3.1.7

3.1.2 Effects of the constructed countermeasure works and evaluation of the maintenance system

- After completion of all countermeasures, groundwater level and landslide activity shall be monitored through at least one rainy season. And, the effects of the landslide countermeasure works should be evaluated by the stability analysis based on the result of the landslide monitoring.

- Regarding the evaluation method of the effect of landslide countermeasures using stability analysis, technical workshop for technology transfer was held by MPI and JICA; and a manual was prepared for this purpose.

- MPI has prepared a work plan for evaluating the countermeasure work in Chitrakoot using the manual.

- As one of the maintenance methods of the landslide countermeasures, the site inspection of the countermeasure in Chitrakoot was carried out on 6 March 2017 by MPI/LMU and JET.

- Generally, in Mauritius, landslide countermeasures are maintained by local authorities. Therefore, MPI and the JICA experts have prepared procedures for maintaining landslide countermeasures to be used by local authorities. MPI will be able to teach the maintenance procedures to the local authorities using this document.

The contents and output of the activity: effects of the constructed countermeasure works and evaluation of the maintenance system, are shown in the table below.

Table 3.1.2 Contents and output of the activity, effects of the constructed countermeasure works and evaluation of the maintenance system (Source: JET)

Date	Item	Contents	Organisation (the number of participants)	MPI/LMU	Reference /Output
06 March 2017	Site inspection for the maintenance of the countermeasure	The inspection of the drainage condition was carried out in Chitrakoot by MPI/LMU and JET.	MPI (2)	• Technical Transfer of the site inspection method for the landslide countermeasure maintenance • OJT	Appendix 3.1.1 Appendix 3.1.8
17 October 2017	Maintenance manual	Procedure manual for the maintenance of landslide countermeasures was prepared.	MPI (5)	• Technical transfer of maintenance of landslide countermeasures • Preparation of procedure manual for maintenance of landslide countermeasures	Appendix 3.1.9
17 October 2017	Technical meeting	Technical meeting for procedure of the maintenance of landslide countermeasures was held by MPI/LMU and JET.	MPI (5)	• Technical Transfer of procedure for the maintenance of landslide countermeasures	Appendix. 3.1.10
15 December 2017	Technical workshop for the evaluation method of the effect of the landslide countermeasure'	The evaluation method of the effect of the landslide countermeasure using stability analysis was transferred to MPI by JICA experts, and a manual for that was prepared.	MPI (15)	• Technical Transfer: The evaluation method of the effect of the landslide countermeasure by the stability analysis • Practical use of procedure manual, Evaluation method for effects of the landslide countermeasure using Stability Analysis	Appendix 3.1.11 Appendix 3.1.12
15 December 2017	Work plan for evaluation of the countermeasure	MPI has prepared a work plan for evaluations of the countermeasure work in Chitrakoot using the manual.	MPI (2)	• Technical Transfer: The evaluation method of the effect of the landslide countermeasure by the stability analysis • Practical use of procedure manual, Evaluation method for effects of the landslide countermeasure by using Stability Analysis	Appendix 3.1.13

3.1.3 Usage of manual

MPI and JICA Expert Team have prepared two manuals, 'Procedure Manual for Landslide' and 'Technical Guideline for Initial Survey' in this project. These two manuals were made in the previous JICA project, and were revised in this project.

'Procedure Manual for Landslide' has been prepared to acquire basic knowledge of landslides and procedures of geological surveying, monitoring, stability analysis and design/maintenance of the countermeasures for landslides.

'Technical Guideline for Initial Survey' has been prepared for responding to a landslide after one has occurred. It includes guidance on initial site surveying, emergency response and planning for detailed landslide surveys.

- Using the above manuals, MPI carried out the detailed design (D/D) of the landslide countermeasures for Chitrakoot
- Using the manuals, MPI carried out the construction of the landslide countermeasures in Chitrakoot
- Using the manuals, a landslide investigation was carried out by MPI in Vallée Pitot
- The construction of landslide countermeasures was carried out using the manuals in Vallée Pitot
- Based on the manuals, MPI has prepared a procedure manual for the maintenance of landslide countermeasures

The contents and output of the activity: usage of manual, are shown in the table below.

Table 3.1.3 Contents and output of the activity, usage of manual (Source: JET)

Date	Item	Contents	Organisation (the number of participants)	MPI/LMU	Reference /Output
05 May 2015	Landslide investigation by MPI in Vallée Pitot	Using a manual, a landslide investigation was carried out by MPI in Vallée Pitot.	MPI (3)	• Practical use of manual, Procedure Manual for Landslide • Landslide investigation	Appendix 3.1.14
06 July 2017	D/D of the countermeasure for Chitrakoot	Using a manual, MPI has carried out the detailed design for Chitrakoot.	MPI (3)	• Practical use of manual, Procedure Manual for Landslide • OJT • D/D	Appendix 3.1.15
06 July 2017	Construction of the landslide countermeasures in Chitrakoot	Using a manual, MPI has carried out the construction of the landslide countermeasures in Chitrakoot	MPI (3)	• Practical use of manual, Procedure Manual for Landslide • OJT • Construction of the landslide countermeasures	Appendix 3.1.1 - 3.1.7
12 October 2017	Construction of landslide countermeasures in Valle Pitot.	The construction of landslide countermeasures was carried out using a manual in Valle Pitot.	MPI (3)	• Practical use of manual, Procedure Manual for Landslide • OJT • Construction of the landslide countermeasures	Appendix 3.1.16
17 October 2017	Maintenance manual	Using a manual, MPI has prepared a procedure manual for the maintenance of landslide countermeasures.	MPI (5)	• Preparation of procedure manual for maintenance of landslide countermeasures • Understanding of the maintenance technique	Appendix 3.1.9

3.1.4 Problems identified and lessons learnt

The countermeasure works in Chitrakoot were divided into two work sections, Phase 1 and Phase 2. Phase 1 had been conducted during the previous project in 2014, and Phase 2 was conducted by the MPI from 20 July to the end of January 2018. The contents of Phase 1 and Phase 2 are included in Section 3.1.1.

MPI and JET identified the problems and the lessons learnt based on the results of the projects, Phase 1 and Phase 2, for landslide countermeasures.

a. Capacity of landslide countermeasure construction and supervision

MPI already has knowledge and experience of construction and supervision for landslide countermeasure, surface drainage, blind ditch and horizontal drain, through a previous JICA project and this project, and can conduct a plan, D/D and construction of appropriate landslide countermeasures. However, MPI does not have experience of landslide prevention work such as anchor work, pile work and shaft work. It will be necessary to acquire knowledge and experience of the landslide prevention work as needed in the future.

b. Relocation of residents

In Mauritius, often one of the most effective countermeasures is to relocate the inhabitants of

the landslide hazard area. MPI is planning the relocation of inhabitants in three pilot sites, Chitrakoot, Vallée Pitot and Quatre Soeurs.

c. Organisation for managing and maintaining countermeasures

Generally, in Mauritius, the landslide countermeasures are maintained by local authorities. However, because the local authorities do not know the maintenance procedures, mostly, maintenance for landslide countermeasures is not carried out. Therefore, MPI and JICA should prepare the maintenance procedures of landslide countermeasures for local authorities.

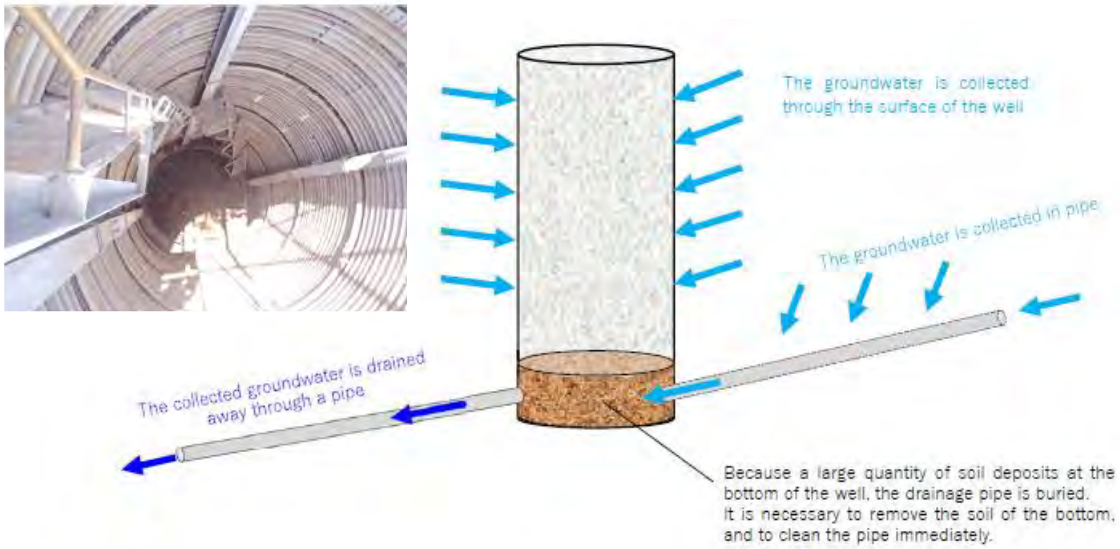


Figure 3.1.4 Existing drainage well in La Butte (Source: JET)

d. Hazard map of landslide disaster

The first step for mitigation of the slope disaster is to know the distribution of the slope angle in detail. If there is a high-resolution slope map as a hazard map in Mauritius, the land development in a steep slope area is easily controlled according to Planning Policy Guidance (PPG) 9. However, the grid data obtained in the previous project was too rough to be used for the PPG. If more high-resolution grid data is acquired in the future, the slope map as a hazard map should be prepared by MPI.

3.1.5 Recommendation

a. Capacity of landslide countermeasure construction and supervision

MPI already has knowledge about planning, D/D and construction of the landslide prevention work in manuals such as on anchor work, pile work and shaft work. However, MPI cannot carry out landslide prevention work by itself because MPI does not have construction experience. The experience of the landslide prevention work will be brought to Mauritius in 2018 by an MPI member currently studying in Japan through the ABE Initiative of JICA.

b. Organisation for managing and maintaining countermeasures

Generally, in Mauritius, landslide countermeasures are maintained by local authorities.

Therefore, MPI and the JICA experts have prepared the maintenance procedure of the landslide countermeasures for local authorities (refer to Appendix 3.1.9). MPI will be able to teach the procedures of maintenance to the local authorities using this document.

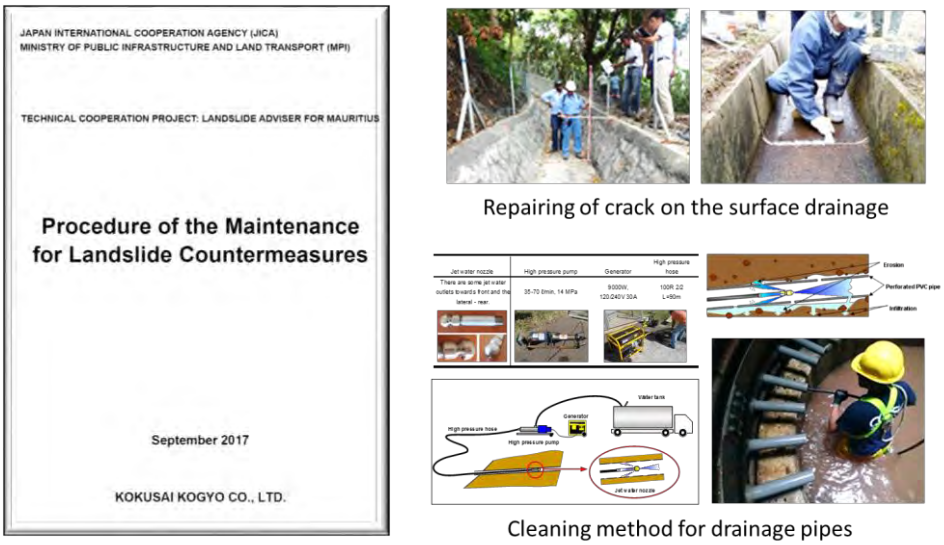


Figure 3.1.5 Procedure of the landslide countermeasure produced by MPI and JET (Source: JET)

c. Hazard map of landslide disaster.

JET held a technical transfer workshop to make a slope map using Geographic Information System (GIS) software (refer to Appendix 3.2.5). If higher-resolution Digital Elevation Model (DEM), < 2 m mesh, is acquired in future in Mauritius, the slope map as a hazard map can be prepared easily using the techniques taught in the workshop by MPI.

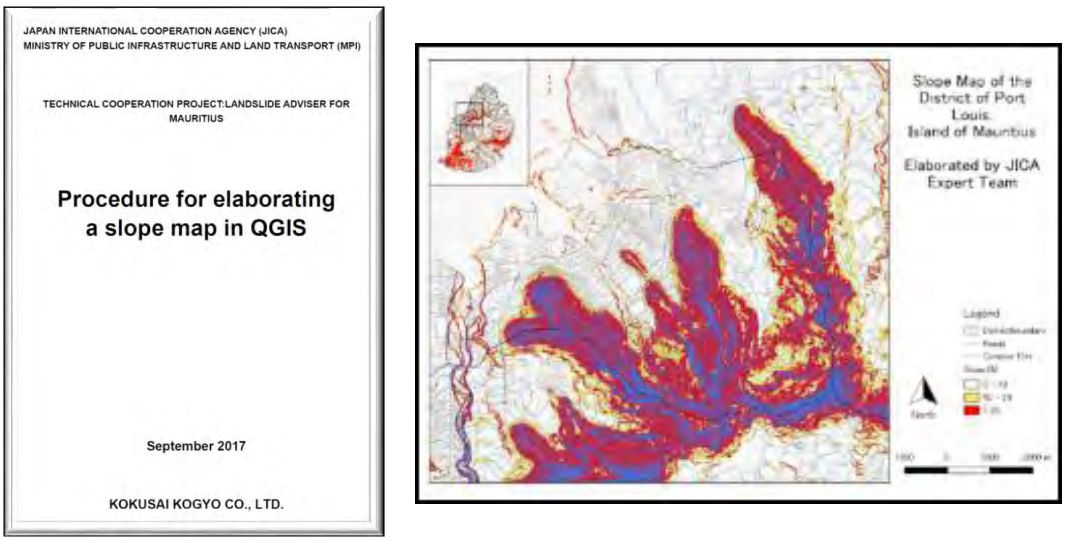


Figure 3.1.6 Procedures for creating slope maps; produced by MPI and JET (Source: JET)

3.2 Technical support on slope failures, rock falls and debris flow countermeasures

3.2.1 Explanation of slope failures, rock falls and debris flows

JET explained three types of slope disasters and their mechanisms (landforms, geology, inducing factors, movement of the soil and rocks, etc.) and the difference between the countermeasures.

Furthermore, JET explained not only structural countermeasures but also factors to take into account (short-period (intense) rainfall and long-period rainfall, groundwater conditions, earthquakes, strong winds) when planning the monitoring and early warning systems.

From March to July 2016, JET conducted field surveys to investigate the mechanisms of slope failures, rock falls, debris flows and their causes in Mauritius. JET also carried out technical transfer of recommendable measures. In addition, JET held two technical meetings and a workshop about slope disasters.

The contents and output of the activity: explanation of slope failures, rock falls and debris flows, are shown in the table below.

Table 3.2.1 Contents and output of the activity, explanation of slope failures, rock falls and debris flows (Source: JET)

Date	Item	Contents	Organisation (the number of participants)	MPI/LMU	Reference /Output
03 March 2016	Technical meeting (1)	• Agenda of Technical meetings for slope failures, rock falls and debris flows • Tendency of slope disasters • Cause of slope disasters • Selection of countermeasure works • Low cost countermeasure works • Explanation of crib walls	MPI (5)	• Basic knowledge of slope failures, rock falls and debris flows • Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow	Appendix 3.2.1
14 July 2016	Technical meeting (2)	• Agenda of Technical meetings for rock falls • Explanation of rock falls (An example of Signal Mountain) • Structural Countermeasures • PPG • Rock fall countermeasure works	MPI (5)	• Basic knowledge of slope failures • Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow	
20 July 2016	Technical meeting (3)	• Agenda of Technical meetings for rock falls • Methods of rock fall countermeasure works • Materials of countermeasure works • Basic design for Maconde and Signal Mountain	MPI/LMU, Road Development Authority (RDA), NDRRMC, Contractor (27)	• Methods of rock fall countermeasure • Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow	

3.2.2 Designation of risk areas and effects of the constructed countermeasure works (evaluations)

a. Designation of risk areas

MPI and JET have visited 18 sites of slope failures, rock falls, and debris flows, and surveyed the current conditions of each slope during this project. As a result of the investigation of the 18 sites, slope investigation sheets and a slope inventory were made by MPI and JET. The slope inspection sheets of the 18 sites are attached as an Appendix at the end of the report.

11 sites designated with a risk rank of A or B are shown in the slope inventory by MPI and JET. The lists of the risk areas are as follows.

Table 3.2.2 List of the designated risk areas and proposed countermeasures (Source: JET)

Management No.	Address/Name	Slope Disaster Type		Risk Rank	Proposed countermeasures by JET and C/P
		Category 1	Category 2		
2016-001	A9 Road at Batelage	SF	CS	A	Crib wall & concrete spraying
2016-002	Valle Pitot	SF	FL	A	Retaining wall
2016-003	Ruisseau de Creoles	RF	DV	A	Rock removal & stabilisation
2016-004	Coromandel, land of Mr. H. Phutully	SF&RF	DV	B	Retaining wall
2016-006	Kewal Nagar Belle Rive at Shavala Road	SF	RE	A	River bank protection wall such as a gabion
2016-007	Application for Building and Land Use Permit at Moka	SF	DV	B	Reforming, re-cutting
2016-008	Signal Mountain	RF	CS	A	Rock removal, stabilization, rock fence and rock fall protection net
2016-009	Mount Ory	SF	DV	B	Reforming, re-cutting
2016-010	Maconde	RF	CS	A	Rock fall protection net
2016-017	Mrs Coolen House, Camp Garreau, Flacq	SF	RE	A	River bank protection wall such as a gabion
2016-018	Hermitage, Coromandel	SF&RF	DV	A	Retaining wall

<Legend>

SF	Slope failure
RF	Rock fall
DF	Debris flow
Dep	Depression
CS	Cut slope for Road
DV	Development
RE	River Bank Erosion
FL	Filling for Road

b. Slope map as a hazard map

The first step for mitigation of the slope disaster is to know the distribution of the slope angle in detail. If there is a high-resolution slope map in Mauritius, the land development in a steep slope area is easily controlled according to PPG 9, and the slope disaster will be mitigated.

Therefore, JET held a technical transfer workshop to make a slope map using the GIS software, QGIS. The existing DEM is the highest resolution data in Mauritius, 10 m mesh data, but it is insufficient for slope map as a hazard map. However, if higher resolution DEM, < 2 m mesh, is acquired in the future in Mauritius, the slope map can be updated easily using the techniques taught in the workshop by an MPI engineer.

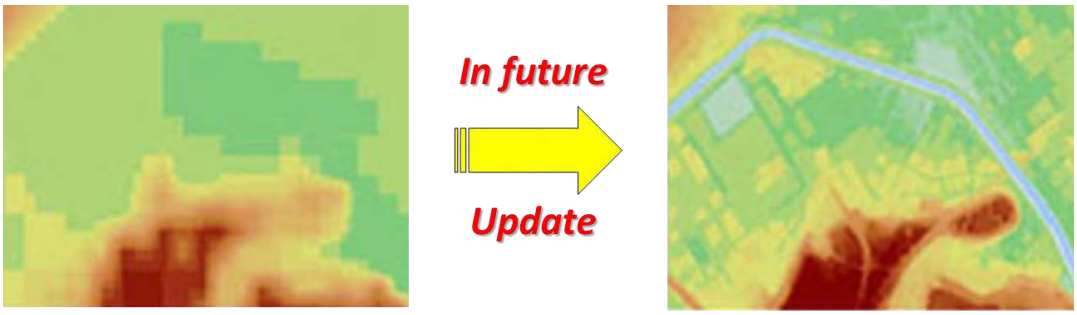


Figure 3.2.1 Difference in resolution in the slope map (Source: JET)

c. Effects of the constructed countermeasure works (evaluations)

Existing slope countermeasures were found only in two sites of the total 18, and it was judged that those countermeasures were insufficient by MPI and JET.

- Management No. 2016-010, Maconde
- Management No. 2016-018, Hermitage

The contents and output of the activity, designation of risk areas and effects of the constructed countermeasure works (evaluations) are shown in the table below.

Table 3.2.3 Contents and output of the activity, designation of risk areas and effects of the constructed countermeasure works (evaluations) (Source: JET)

Date	Item	Contents	Organisation (the number of participants)	MPI/LMU	Reference /Output
31 October 2016	Slope inventory	MPI and JET visited 18 sites of slope failures, rock falls, and debris flows, and a slope inventory was made by MPI and JET.	MPI (5)	• Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow • OJT	Appendix 3.2.2
31 October 2016	Slope investigation sheets	MPI and JET visited 18 sites of slope failures, rock falls, and debris flows, and slope investigation sheets were made by MPI and JET.	MPI (5)	• Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow • OJT	Appendix 3.2.3
31 October 2016	Effects of the constructed countermeasure works (evaluations)	Existing slope countermeasures were found in two sites of the total 18, and MPI and JET evaluated those countermeasures to be insufficient.	MPI (5)	• Practical use of manual, manual for survey and countermeasure of slope failure, rock fall and debris flow • OJT	Appendix 3.2.4
11 October 2017	Technical workshop for making a slope map by GIS software	JET held a technical transfer workshop to make a slope map by GIS software, QGIS. If more high-resolution DEM, < 2 m mesh, is acquired in the future in Mauritius, the slope map as a hazard map can be updated easily using the technique of the workshop by MPI engineer.	MPI (15)	• Technical transfer: Procedure to make a slope map by QGIS • Practical use of procedure manual, procedure for elaborating a slope map in QGIS	Appendix 3.2.5

3.2.3 Support for formulating the manual/guideline of slope failures, rockfalls, and debris flows

In accordance with the currently employed landslide countermeasure manual, JET is supporting the elaboration of two manuals called 'Technical Guideline for Initial Survey' and 'Procedure Manual for Landslide'. The contents focused mainly on actual surveys and measures.

JET led the work to summarise the knowledge LMU and JET had gained through various instances, including the field surveys and the countermeasure work planning carried out in 2017.

'Technical Guideline for Initial Survey' and 'Procedure Manual for Landslide', which were made during the Previous Project, were brought in as a reference. Manuals concerning slope failure such as those created by JICA, the Japanese Ministry of Land, Infrastructure Transport and Tourism, or the Public Works Research Institute were not used, because the manuals created by JET were made having in mind the cases in Mauritius so that MPI and LMU will be able to use the manual easily.

The contents are as shown below. Each article describes slope failures, rock falls and debris flows respectively. Each countermeasure work is also explained in detail in the manuals of slope failures, rock falls and debris flows.

Table 3.2.4 Contents of the manual of slope failures, rock falls, and debris flows (Source: JET)

Chapter	Sub-Chapter	Contents
1 Introduction	1.1 What is landslide?	Definition of landslide, type of slope disasters in Mauritius. Location map and inventory
	1.2 Procedure manual of slope failures, rock falls and debris flows	Basic procedures and contents, proceedings of slope earthworks
	1.3 Explanation of technical terms	
2 Surveys	2.1 Introduction	Relationship between procedure of slope earthwork and soil investigation, survey method
	2.2 Survey on slope failures	Checkpoints of survey, cut slope and natural slope failures, survey on cut slope stability, survey on slope failures requiring extra precautions, surveys for planting
	2.3 Survey on rock falls	Checkpoints of survey, survey on rock fall requiring extra precautions
	2.4 Survey on debris flows	Checkpoints of survey, survey on occurrence of debris flows, survey on estimation of scale, character and inundation area of debris flows
	2.5 Survey on drainage systems	Checkpoints of survey, survey on drainage system for surface water, survey on drainage system for seepage water
	2.6 Survey on retaining wall and culvert	Checkpoints of survey, survey on retaining wall and culvert
3 Design	3.1 Introduction	Basic principles and important points for design
	3.2 Cut slopes	Standard cross-section of cut slopes. Cuts requiring extra precautions
	3.3 Slope protection	Selection of slope protection works, important points for introduction of slope protection works, planting, slope protection works with structures
	3.4 Countermeasures for rock	Selection of countermeasures for rock falls, important

	falls	points for application of countermeasures for rock falls
	3.5 Countermeasures for debris flows	Selection of countermeasures for debris flows, important points for countermeasures for debris flows
	3.6 Drainage	Road drainage, surface drainage, slope drainage, subsurface drainage, transverse drainage across road, drainage during construction work
	3.7 Retaining wall	Selection of structural and foundation types, determination of design conditions, earth pressure, stability analysis for retaining wall, design of various types of concrete retaining walls, design of foundations, design of drainage, design of reinforced soil wall
	3.8 Culvert	Selection of structural type, roads used for design of culvert, important points for design of various types of culvert, design of foundations
4 Execution	4.1 Introduction	
	4.2 Slope work	Cut slope work, embankment slope work, slope protection work
	4.3 Countermeasures for rock falls and debris flows	Countermeasures for rock falls, countermeasures for debris flows
	4.4 Construction of retaining wall and culvert, etc.	Construction of retaining wall, construction of culvert, execution of backfilling and approach cushion
5 Work Management and Inspection	5.1 Introduction	
	5.2 Execution management	Schedule control, quality and finished work control, environmental conservation measures
	5.3 Work inspection	Finished work inspection methods, quality inspection methods, acceptance judgment
6 Maintenance of Earth Structures	6.1 Introduction	Necessity for and components of maintenance, important points for maintenance, disaster restoration measures
	6.2 Maintenance of slopes	Inspection of slopes, maintenance and repair of slopes, countermeasures for post-completion abnormalities
	6.3 Maintenance of drainage facilities	Inspection of drainage facilities, maintenance and repair of drainage facilities
	6.4 Maintenance of retaining walls and culvert	Inspection of retaining walls and culvert, countermeasures for distortion of retaining walls and culvert

3.2.4 Usage of Manual

MPI and JICA Expert Team have prepared a manual titled 'Manual for Survey and Countermeasure of Slope Failure, Rock Fall and Debris Flow' in this Project. This manual mentions survey, inspection, D/D and maintenance of the countermeasures for slope failures, rock falls and debris flows.

Using a manual, JET transferred the techniques of countermeasures, structural and non-structural countermeasures, for slope failures, rock falls and debris flows, including the implementation of surveys, analyses, designs, construction supervision, management and maintenance to the LMU through OJT.

The main points are as follows:

- Construction works: technical transfer of construction, management and maintenance
- Planning countermeasure works: technical transfer of surveys, designs, constructions, management and maintenance

- Constructed works: technical transfer of management and maintenance

The following sections describe the technical transfer works carried out at each site.

Table 3.2.5 Summary of surveys and measures against slope failures, rockfalls, and debris flows, and technical transfer (Source: JET)

Name of the sites	Date and attendants (number of participants)	Items and results of survey	Items and results of countermeasures	Reference
1. Batelage (road cut slope failure)	• 15, 17 and 23 February 2016: MPI (2) • 7 July 2016: MPI (1) • 7 October 2016: MPI (2), RDA • 20 October 2016: MPI (1), NDRRMC, Savanne District Council, Police Office and RDA • 26 September 2017: MPI (1), RDA	• Classification of the type of failure • Main cause of slope failure was rain and wind during the cyclone in 2015 • Water drainage from the houses influenced the slope stability	• Cut trees, shaping the slope, removal of unstable rocks • On site crib wall, soil nailing, rock bolts, shotcrete, and retaining wall • Improvement of sewage water	Appendix 3.2.6
2. Signal Mountain (rock falls and debris flows)	• 21,22 and 27 June 2016: MPI (2) • 5 July 2016: MPI • 12 July 2016: MPI (2) • 19 July 2016: MPI (2), NDRRMC • 1 and 5 August 2016: MPI (2) • 24 and 26 October 2016: MPI (2) and Special Mobile Force (SMF)	• Rock fall, road settlement, and debris flow in the 3 km long road section • Classification of rockfall type • Mechanism analysis of rock fall • Mechanism analysis of erosion and debris flow	• Preparation of rock fall countermeasure protocol • Planning of rock fall survey • Preparation of rock fall inventory • Non-structural countermeasures, such as Information boards, sign poles, and traffic regulations • Structural countermeasures-stabilisation, removal, protection measures by structures • Training of rock fall survey and preparation of the inventory	Appendix 3.2.6
3. Maconde (rock fall)	• 21 July 2016: MPI • 21 July 2016: MPI • 26 July 2016: MPI • 25 October, 4 and 7 November 2016: MPI (2) • 26 September 2017: MPI (2) and RDA	• Steep scarp along the B9 road. • Geology of the scarp is alternating beds of basalt lava and blocks • Rock fall occurred frequently	• RDA changed the road alignment from the scarp side to the sea side and constructed a rock fall protection fence. • RDA removed unstable rocks from the scarp • NDRRMC discussed the rock fall countermeasure protocol • Information boards and road signs were set on the road. Traffic regulation was discussed. • LMU and JET discussed countermeasure works and estimated its cost.	Appendix 3.2.6
4. Hermitage (slope failure and rock fall)	• 21 October 2016: MPI (2)	• Artificially modified slope with risk of slope failure. Cause of the slope failure was improper development. • LMU conducted survey of the slope	• LMU designed a retaining wall, a rock fall protection fence and drainage channels • LMU and JET conducted site survey for countermeasure works	Appendix 3.2.6
5. Mount Ory (M1)	• 21, 22 and 27 June 2016: MPI (2)	• District Council of Moka requested LMU to conduct an emergency investigation • Topographic survey by Laser equipment • Slope gradient is in the critical line of 20 %	• LMU prepared a site report to District Council of Moka • Detailed topographic survey is needed to define the border line of slope gradient 20 %	Appendix 3.2.6
6. Mount Ory (Moka)	• 29 March 2016: MPI (2)	• District Council of Moka requested LMU to carry out a survey of 'Application for the use of slope'. • Topographic survey by Laser equipment • Slope gradient is in the critical line of 20 % • Back side slope is prone to rock falls.	• LMU prepared a site report to District Council of Moka • Presumed gradient of this slope will be more than 20 % • Detailed topographic survey is needed in order to define the border line of slope gradient 20 %	Appendix 3.2.6
7. Ruisseau Créoles (rockfall)	• 27 February 2016: MPI (2) • 24 May 2016: MPI (1) • 7 July 2016: MPI (1) and survey team	• There are several boulders in slopes on housing premises (behind the houses). • Major type of rock fall is rolling. • As the slope gradient is between 15 and 20 degrees, the reach of the rock fall will not be long.	• LMU and JET carried out site surveys, and discussed risks and countermeasures. • Hazardous rocks were identified.	Appendix 3.2.6
8. Camp Garreau, Flacq (river erosion and slope failure)	• 9 August 2016: MPI (1)	• The failure was caused by sewage water, rain water, and river erosion.	• The cost of countermeasure works is likely to be expensive. MPI recommended those houses move from this area.	Appendix 3.2.6
9. Kewal Nagar/ (1) Belle Rive (2) river erosion	• 3 and 4 March 2016: MPI (1) • 29 March 2016: MPI (1) • 18 November 2016: MPI (1)	• The slope failure is produced due to river erosion and artificial modification. • Man-made steps of several meters wide can be seen. • The geology of the slope is highly weathered rock and clayey soil.	• Ministry of Social Security, National Solidarity, and Environment and Sustainable Development (MSSNSESD) visited this site and commented on this problem. • Some relation with river water erosion fluctuation to the slope is observed. • LMU recommended Gabion protection against erosion.	Appendix 3.2.6
10. Coromandel (slope failure)	• 1 August 2016: MPI (1)	• There are a lot of unstable rocks on a steep slope. • Rain water flowed down from the road located above of the slope, and caused instability. • Land owner submitted application of development to build a house.	• Recommended not to do slope modification and excavation. • Removal of unstable rocks. Construction of a retaining wall, and drainage channel works are recommended by LMU and JET.	Appendix 3.2.6

11. Petit Bel Air (cut slope failure)	• 29 February 2016: MPI (1) • 3 March 2016	• The slope is near the mouth of Riviere des Creoles. • The geology of the slope is highly weathered rock. • Cut slope was done by the land owner in the lower part of the slope.	• LMU and JET advised residents living above the slope to cut unstable trees, to cover their land with stones and lawn, and to drain water properly. • As the slope is inside a private plot, MPI cannot carry out countermeasure works.	Appendix 3.2.6
12. Vallée Pitot (bank slope failure)	• 16 February 2016: MPI (5) • 26 February 2016: MPI (2)	• The target site is a mountain foot slope. This area is affected by development pressure due to the expansion of urban areas. • Slope failure was caused by a flash flood flowing from the mountain slope and the water saturation of road fill materials. • Damages were inundation, failure of a retaining wall and road collapse.	• Countermeasure for flash floods • Improvement of the weak retaining wall. • Improvement of the surface drainage system along the road. • LMU and JET suggested water shed management on the slope area.	Appendix 3.2.6
13. Long Mountain (river slope failure)	• 8 July 2016: MPI (1) • 15 July 2016	• The subject slope was created by river erosion. • Damage in the slope was not caused by river water but surface water coming from the house yard. • The foundation of the house was slightly washed out.	• Diversion of surface water from the house yard. • An urgent countermeasure is the reinforcement of the foundation.	Appendix 3.2.6
14. Signal Mountain, Maconde and Batelage	• 26 October 2016: MPI (2) and SMF • 7 November 2016: MPI (2) • 7 July 2016: MPI (1)	• Signal Mountain: Support for creating the protocol for rockfalls • Maconde: Support for drafting documents on measures against rockfalls • Batelage: Support for drafting documents on measures against road cut slopes	• Signal Mountain: Making the ‘Manual for Rock Fall Inventory at Signal Mountain Road’ • Maconde: D/D for road alignment, rock fall protection fence and rock net. • Batelage: D/D for a crib wall, soil nailing, rock bolts, shotcrete, and retaining wall	Appendix 3.2.7

3.2.5 Problems and lessons learnt

JET and the C/P selected the problems and arranged lessons to be learned so that MPI will be able to implement the countermeasures independently based on the results of the current implementation status of MPI's project plan for slope failures, rock falls and debris flows countermeasures.

a. Regulation of slope development by PPG

The Development on number of slopes has been given priority, therefore, inspections based on the PPG and on-site instructions at problematic areas are being postponed. Hence the reason, it is necessary to publicise the rules on slope development, because most of the disastrous slopes are located in these areas and many slope disasters happened due to such reckless development. Moreover, expansion of local houses has obviously become a potential danger. These geographical developments are likely to trigger other disasters in the future.

Cases in Moka Region and Mount Ory are typical examples. One of the target slopes is located along the M 1 motorway between Port Louis and Phoenix, where the colluvial deposit slope (talus) in the lower part of a steep slope was designed and developed without permission. The other slope is a little distance from the M 1 motorway, and its geological characteristics are similar with the previous site.

- Both of these sites have already been developed.
- The angle of land before the development is thought to be more than 20 degrees.
- The valley side of the slopes might cause landslides. The mountain sides of the slopes were so steep that they were likely to cause rock fall disasters.
- Development can make the slopes unstable.

Photo 3.2.1 Panoramic view of survey site (Source: JET)

Since the development at the slopes with gradients of more than 20 % is forbidden, a preliminary review system based on PPG needs to be established according to which District and Municipal Councils will give administrative approval or denial for development. After

the approval for development, LMU is expected to give the necessary slope countermeasures instructions to the contractors.

b. Preparation of detailed hazard map

Regulation of slope development is an important process to halt the increase of areas of risk. For that reason, it is urgently needed to make a slope classification map. The 20 m grid data obtained in the previous project was too rough to be used for the PPG. Though JET requested detailed digital data to MHL for Port Louis and Moka region, simpler data was obtained, so another request to MPI is necessary.

c. Establishment of the registered surveyor system

After primary approval for development has been given according to the slope classification map, survey of slope inclination on the planned site for development will be required.

d. Necessity of comprehensive basin management

Landslides or flash floods occurring at the foot of mountains are closely related to slope development and land use. Efforts for conservation of forests, tree planting and prevention of wild fire serve for the consolidation of surface soil, prevention of erosion and rockfalls, and control of surface runoff or floods. Furthermore, measures against landslides and road maintenance may include drainage of surface water, increase influx into the rivers and can cause floods downstream. Therefore, a comprehensive watershed management which takes the entire catchment area into account will be indispensable hereafter.

e. Increasing rock fall prone slopes

Rock falls have been an obvious risk at slopes along roads and steep slopes behind houses. In the natural state, unstable rocks are kept from falling by bushes and shrubs. However, some rocks on artificial slopes are not supported or sustained by such things, endangering roads and houses below. Unless adequate measures are taken, slope development will keep on increasing the risk of rock falls.

f. Few streams with risk of producing debris flows

When it comes to debris flows, there are a few torrent streams in Mauritius. Therefore, debris flows hardly occur. The debris flows are like floods in the sense that they contain less soil and sand than water. Preservation of forests in the basins is important as a measure in sites where there is risk of debris flow occurrence. Measures employing check dam are not cost efficient. Instead, small-scale river management along villages and bridges will often work.

g. Relocation of residents

It seems a very adequate decision both technically and economically to focus on relocating local residents as a measure against slope disasters. The existing plan that LMU made concerned three pilot sites in danger of landslide and involved transfer of residents. The impression of JET was that the most realistic and effective landslide countermeasures were in being carried out.

3.2.6 Recommendation

Furthermore, JET proposed countermeasures management and maintenance plans for slope failures, rock falls and debris flows.

a. Preparation of detailed hazard map

Regulation of slope development is an important process to halt the increase of areas of risk. For that reason, it is urgently needed to make a slope classification map. Referring to the precise landform data, the slope classification map will need to be made on a trial basis to regulate unauthorised development with the cooperation of MHL. Once the slope classification map is completed, its application method should be described in the PPG.

JET held a technical transfer workshop to make a slope map using GIS software (refer to Appendix 3.2.5). If higher-resolution DEM, < 2 m mesh, is acquired in future in Mauritius, the slope map as a hazard map can be prepared easily using the techniques taught in the workshop by MPI.

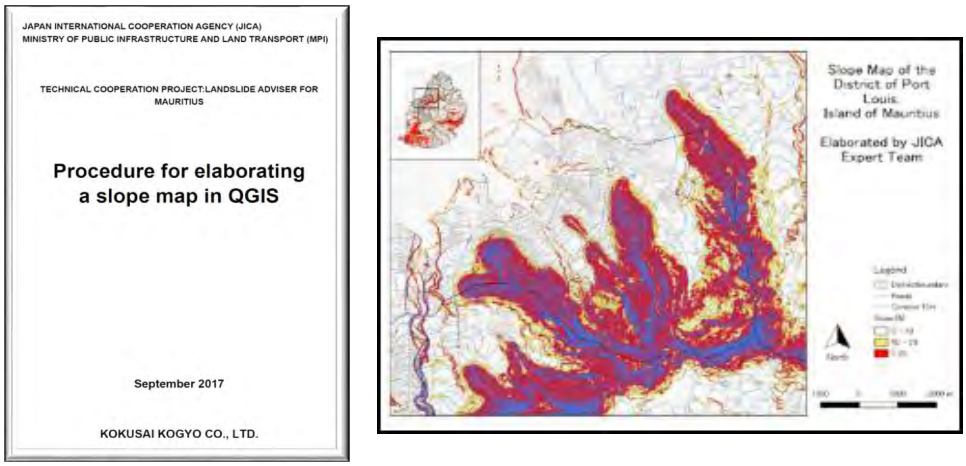


Figure 3.2.2 Procedures for creating slope maps; produced by MPI and JET

b. Establishment of the registered surveyor system

Although survey for housing plots may be conducted by a surveyor that belongs to the contractor, the final survey must be conducted by a reliable official surveyor. System for such authorised surveyors should be established.

c. Increasing rock fall prone slopes

Unless adequate measures are taken, slope development will keep on increasing the risk of rock falls. The presence of unstable rocks must be searched not only in the nearby slopes but also in a wider area behind the construction site before development works begin.

d. Relocation of residents

The impression of JET was that the most realistic and effective landslide countermeasures were in being carried out. In Mauritius, often one of the most effective countermeasures is to relocate the residents of the landslide hazard area.

3.3 Technical support for establishing a remote monitoring system for slope disasters

3.3.1 Current monitoring system

In the Previous Project, landslide monitoring has been implemented at three sites, Chitrakoot, Vallée Pitot and Quatre Soeurs, and the MPI started monitoring the landslides at several sites additionally. Subsequently, JET and C/P have confirmed the current situation of landslide monitoring and the monitoring system.

Landslide monitoring is currently carried out by MPI in three sites, Chitrakoot, Vallée Pitot, and Quatre Soeurs. In addition, landslide monitoring with extensometers in La Butte and Vallée pitot was installed in 2015. The measurement items installed in each site and the condition of the monitoring equipment are shown in Appendix 3.3.1.

3.3.2 Problems and lessons learnt

The problems and lessons learnt for a remote monitoring system are as follows; MPI already has knowledge and experience of the landslide monitoring through a previous project, and can plan appropriate landslide monitoring. However, MPI does not have techniques needed for a remote monitoring system. MPI, with assistance of JET, should prepare a plan of the remote monitoring system in this project.

- In Mauritius, a cell-phone communication network is useful for data transmission for remote monitoring. A Global System for Mobile Communication (GSM) network is particularly convenient because it is the most widely used communications network globally. MPI should plan a remote monitoring system using GSM.

- Multiple landslides are the target of the remote monitoring. The remote monitoring system must be able to observe multiple landslides at the same time.

- The warning of the remote monitoring system should reach the various people and parties concerned such as NDRRMC, the police and MPI. Therefore, using mobile phone Short Message Service (SMS) is a realistic technique. Because those concerned can receive SMS warnings simultaneously, NDRRMC can respond to a landslide disaster without waiting for the judgment of MPI.

3.3.3 Recommendations for structure of monitoring system

Since MPI cannot go to all the sites when cyclones that activate landslides occur, the monitoring results cannot be confirmed in real time. MPI can confirm monitoring results at any time without being influenced by climatic conditions and traffic conditions if a remote monitoring system is introduced.

Therefore, JET and the C/P have been studying remote monitoring systems and recommended a structure of remote monitoring system that suit Mauritius. The assumptions for studying the landslide remote monitoring system are as follows:

- There are three sites to install/implement the remote monitoring system;

- Sites to be monitored are Chitrakoot, Vallée Pitot and La Butte; and
- The implementation flow of the remote monitoring system is shown in the figure below.

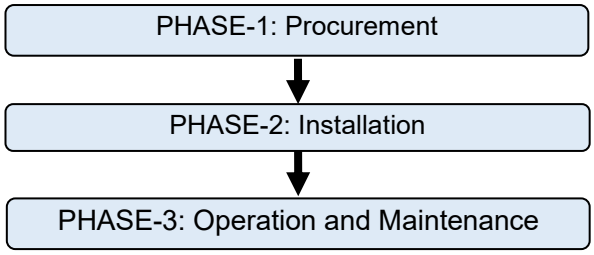


Figure 3.3.1 Implementation flow of the remote monitoring system (Source: JET)

Figure 3.3.2 Image of the remote monitoring system (Source: JET)

3.3.4 Study and recommendations on the remote monitoring system

According to '3.3.3 Recommendations for structure of monitoring system', MPI and JET have proposed a remote monitoring system that is suitable for Mauritius. The proposed remote monitoring system is shown in Appendix 3.3.2.

3.4 Technical support for updating the early warning/evacuation system based on the results of the countermeasures for slope failures, rock falls and debris flows

3.4.1 Early warning/evacuation system in Chitrakoot / Vallée Pitot

In the Previous Project, landslide Early Warning System (EWS), consisting of extensometers and alert equipment, has been implemented at Chitrakoot and Vallée Pitot. Also, another EWS has been added in Vallée Pitot by MPI in 2015. Early warning/evacuation system in Chitrakoot / Vallée Pitot are shown in Appendix 3.4.1.

The equipment and the structure of the landslide EWS are shown below.

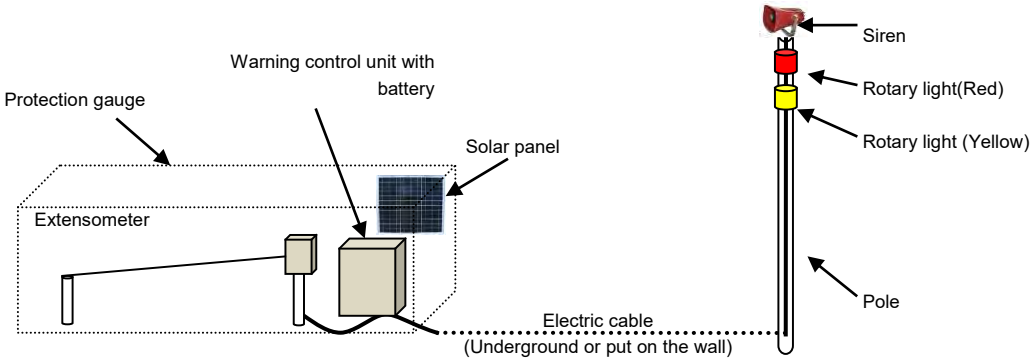


Figure 3.4.1 Conceptual diagram of EWS (Source: JET)

Table 3.4.1 Quantity of the parts for the EWS (Source: JET)

Location	Name	Quantity	Remarks
Chitrakoot	Siren	1	Previous Project by JICA, 2014
	Rotary light (red)	1	
	Rotary light (yellow)	1	
	Warning control box	1	
	Solar panel	1	
Vallée Pitot	Siren	1	Previous Project by JICA, 2014
	Rotary light (red)	1	
	Rotary light (yellow)	1	
	Warning control box	1	
	Solar panel	1	
Vallée Pitot	Siren	1	Other projects by MPI, 2015
	Rotary light (red)	1	
	Rotary light (yellow)	1	
	Warning control box	1	
	Solar panel	1	

3.4.2 Problems identified and lessons learnt

EWS has been installed recently in Mauritius. Current problems identified and lessons expected to be learned are as follows.

- Capacity of planning and designing EWS; MPI already has knowledge and experience of the EWS for landslide through a previous project, and can plan appropriate landslide EWS.

- Proficiency level for the operation of the monitoring equipment; after a previous JICA project, the additional EWS in Vallée Pitot was planned and installed by MPI in 2015. Three existing EWSs in Chitrakoot and Vallée Pitot are operated appropriately now by MPI.

- Operation system; the existing EWS can give a warning alert by a siren and a rotary light automatically on site. However, it cannot transmit measurement data and a warning to MPI. The existing EWS should be upgraded as a remote monitoring system in the future (refer to 3.2.3)

- Maintenance of the equipment; as maintenance of the apparatuses, the removal of weeds and exchange of the battery should be carried out regularly before a problem occurs. In addition, simple instruction manuals for EWS should be prepared.

- Knowledge, advanced technique, and experience in EWS for slope disasters (excluding landslides); the knowledge and the experience of the EWS for the landslide were brought to MPI through this project and a previous project. However, the preparations for EWS for slope failures, rock falls and debris flows are still insufficient. An automatic rainfall monitoring system and the slope map as the slope disaster hazard map are necessary for the EWS.

3.4.3 Proposal for the improvement of EWS

JET has studied the current system to provide proposals for making improvements in the early warning systems and evacuation procedures for slope failures, rock falls and debris flows.

a. Simple instruction manuals for EWS

As maintenance of the apparatuses, a simple setting manual for EWS has been prepared by MPI and JET (refer to Appendix 3.4.2).

b. An automatic rainfall monitoring system

An automatic rainfall monitoring system is necessary for the EWS. However, it is not easy to install an automatic rainfall monitoring system covering the whole island. Therefore, MPI suggested the use of Automatic Weather System (AWS) of Mauritius Metrological Service (MMS). In response to a request from MPI, MMS installed AWS in Chitrakoot in December 2016 (refer to Appendix 3.4.3). The JET proposes that AWS of MMS be expanded to cover the whole island. In addition, the use of a weather radar installed by another JICA project is expected in the future.

c. The slope map as the slope disaster hazard map

The slope map as the slope disaster hazard map is necessary for the EWS. Therefore JET held a technical transfer workshop to make a slope map using GIS software (refer to Appendix 3.2.5). If high-resolution DEM, < 2 m mesh, is acquired in the future in Mauritius, JET proposes that MPI makes a slope map as a hazard map using the techniques taught in the workshop.

3.5 Public awareness and sensitisation materials

3.5.1 Original sensitisation materials in the Previous Project

The 'landslide disaster prevention handbook (hereinafter 'landslide handbook')' was developed as a tool to disseminate landslide information to the local residents under the Previous Project. The JET found through the questionnaire survey and meetings that the level of understanding about landslide issues as well as early warning and evacuation systems was low among the local residents in the landslide prone areas. Consequently, JET decided to prepare the handbook which summarised the basic information of landslide, disaster preparedness and measures to cope with landslide.

The landslide handbook was published in both English and French. It was distributed to the local residents living in three landslide priority areas; Chitrakoot, Vallée Pitot and Quatre Soeurs. It was also distributed to the stakeholders during the technical seminar and steering committee.

3.5.2 Revision of the sensitisation materials

a. Process of updating the sensitisation materials

As the handbook developed under the Previous Project focused on landslide only, it must be updated with additional information including slope failure, rockfall and debris flow in this Project. Moreover, JET must consider the comments and suggestions on the previous handbook from the related stakeholders when they use it. Consequently, JET conducted questionnaire surveys to find out the quality of the handbook as well as to obtain their comments to improve it. While the first questionnaire survey was conducted in April 2016, the second one was in March 2017. The results of the questionnaire surveys are as attached (Appendix 3.5.1).

b. Revised items

According to the survey results, the feedback was relatively positive. The readers could improve their knowledge on landslides after reading the landslide handbook. However, at the same time, there are a number of comments and suggestions to further improve the contents. Also, JET and MPI carefully reviewed the handbook. The major comments and suggestions are as follows:

1. The handbook should be simplified with less literature and more illustrations/diagrams/cartoons
2. It should avoid technical terms
3. Information such as emergency shelters and emergency contact numbers should be added
4. Disaster preparedness including psychological preparedness should be added
5. Practical precautions of what to do during and after a slope disaster should be added
6. Creole version should be considered in order to sensitise a greater number of people

7. Countermeasure works in Chitrakoot needs more explicit information

8. Institutional framework should be included and the roles of each institution needs to be explained

9. Proof reading is necessary as there are grammatical and typological mistakes, especially in the French version

Based on the comments and suggestions, the material was updated and renamed the 'slope disaster preparedness handbook (hereinafter 'slope disaster handbook')'. Also, in response to the requests from the stakeholders, the Creole version of the 'slope disaster preparedness leaflet (hereinafter 'slope disaster leaflet')' was developed.

The comments No. 1 to 6 mentioned above were taken into consideration for the slope disaster handbook/leaflet which is summarised in tables 3.4.1 and 3.4.2. For comment No. 7, as the slope disaster preparedness handbook covers more different types of slope disasters, the chapter specialised in landslide was deleted. Moreover, regarding the institutional framework in comment No. 8, it is not mentioned in the slope disaster handbook because the responsible unit in the MPI has not been clearly established yet. For comment No. 9, the Government Information Services (GIS), which is responsible for disseminating information on government policies, programmes and services, supported checking the language accuracy as a public relations officer had not yet been posted to the LMU. The overall updating works of the English/French handbook and developing works of Creole leaflet were done with the support of the GIS.

Table 3.5.1 Main features of sensitisation materials (Source: JET)

	<Previous Project>	<Current Project>	
	Landslide disaster prevention handbook	Slope disaster preparedness handbook	Slope disaster preparedness leaflet
Topic	Landslide	Landslide, slope failure, rock fall and debris flow	Landslide, slope failure, rock fall and debris flow
Language	English/French	English/French	Creole
Style	A5 brochure (24 pages)	A5 brochure (8 pages)	A4 tri-folded leaflet
Features for updated version		• Less pages • Less text • Less technical terms • More local photos • More illustration • More practical information	• Most important messages extracted from English/French handbook

Table 3.4.2 specifically explains which contents have been deleted or added, by comparing the slope disaster preparedness handbook to the landslide disaster prevention handbook.

Table 3.5.2 Comparison of contents in the handbooks

<Previous Project> Landslide disaster prevention handbook	<Current Project> Slope disaster preparedness handbook	Reasons of addition/deletion and remarks for slope disaster handbook
(1). Aim of handbook	① Slope disasters and causes	• (1) Aim of handbook was deleted to reduce total number of pages • (2) What is landslide: In addition to landslide, definition, causes and signs of slope failure, rock fall and debris flow are added to ① Slope disasters and causes and ② signs of warning • (3). Landslide in Mauritius is shifted to ④ Slope disasters in Mauritius • (4) Why landslide occurs? added to ① slope disasters and causes • (5) features are combined with ④ slope disasters in Mauritius • (6) Development activities in a landslide area is deleted as policy should be considered by the Government, not by the public • (7) Ways of coping with landslide is deleted as slope disaster handbook covers wider topics, and it does not focus on only landslide • (8) Early warning and evacuation system is deleted as the system applies to landslide only • Contact numbers in (9) Emergency contacts are blank in landslide disaster prevention handbook, but were added to slope disaster preparedness handbook. Contact number of shelters are also added
(2). What is landslide?	② Signs of warning	
(3). Landslide in Mauritius	③ Features of slope disasters	
(4). Why landslide occurs?	④ Slope disasters in Mauritius	
(5). Features of a landslide area	⑤ Disaster preparedness	
(6). Development activities in a landslide area	⑥ Do's and Don'ts during slope disasters	
(7). Ways of coping with landslide	⑦ Emergency contacts and shelters	
(8). Early warning and evacuation system		
(9). Emergency contacts		

The final version of the handbook and leaflet is attached as Appendix 3.5.2. It was officially handed over from His Excellency Mr. Kato, Ambassador of Japan, to Honourable Bodha, Minister of MPI in the opening ceremony of the workshop/seminar on the 6th of December 2017.

3.5.3 Distribution of the handbook and leaflet

In the questionnaire surveys, there were some comments on distributing the materials such as:

- Sensitisation activity should target specific groups such as general public, students and senior citizens
- Community participation is essential to disseminate information
- Dissemination process should be carefully considered, for example, distributing to the schools would be effective as students sensitise their parents and relatives
- Public in the landslide prone areas should be sensitised first

After a series of discussions on the distribution plan with the GIS and Civil Engineering Section (CES) of the MPI, the principle of distribution plan was concluded as follows:

- Distributing to the related stakeholders as they have supported revising/developing the materials

- Distributing to the schools as school kids often influence their family, relatives and neighbours

- Distributing to the community facilities that a lot of people use

- Distributing to the 15 slope disaster prone areas as public in these areas are most vulnerable to the slope disasters

List of distributing organisations is attached as Appendix 3.5.3. The handbooks and leaflets were distributed according to the distribution plan except for the public. For the public in the 15 slope disaster prone areas, the MPI in collaboration with the related municipalities will organise a sensitisation session to explain slope disasters followed by distribution of the materials.

The slope disaster handbook and leaflet will be uploaded on the MPI website so that anyone can access the materials at any time. The uploading has been underway after the official launching on 6 December 2017.

3.6 Continuous support for organisation enhancement of the MPI/LMU

3.6.1 Analysis and evaluation of organisation enhancement conducted under the Previous Project

JET conducted interviews with the LMU engineers in April and December 2016 to find out the status of issues and targets identified under the Previous Project. The interview results are summarised in the table below.

Table 3.6.1 Progress of the capacity development plan from the Previous Project (Source: JET)

Issues	Targets	Progress of the capacity development plan
Insufficient knowledge and experience of the LMU	Enhancing technical knowledge and experience	<improvements> • On site knowledge and experience: Basic technology was transferred under the previous project. Further technical transfer has been continuously conducted in this project. • Academic knowledge: One of the LMU engineers has been selected as an ABE Initiative scholar and has studied in the MA of landslide programme in Niigata University since 2015. • Knowledge enhancement through JICA training: Two LMU engineers participated in JICA's knowledge co-creation programme of 'Disaster management for landslide and sediment-related disasters' for two months from October to December 2016. • Technical exchange with the other countries: The engineer studying in Japan participated in the international landslide conferences and presented his research outcomes as well as sharing technical knowledge and information with the other participants.
Insufficient staff in the LMU	Securing sufficient and appropriate staff	<improvements> • Engineers: LMU engineers have been assigned on a full time basis instead of part time and the number of engineers has increased from six to 10 as of April 2016. <further improvements required> • Public relations officer: MPI Head Office promised to post the officer to the LMU in March 2014. However, the officer has not been posted yet. An intern or part time officer will be recruited until the officer is officially posted. • In-house consultant: Consulting works to the private firms have been discussed if necessary.
Weak coordination with the other stakeholders	Improving the LMU's management capacity for landslide sector	<further improvements required> • Task sharing among the stakeholders: Although tasks and responsibilities of each stakeholder were defined and proposed in the previous project, LMU has taken most of the tasks and responsibilities due to limited understanding by the stakeholders.
Evacuation plan and emergency communication network are not fully developed	Prompt response in emergency situations	<improvements> • Procedures in an emergency have been clearly defined in the National Disaster Scheme • LMU's emergency operational system has been established <further improvements required> • The institutional support for the LMU, particularly for the off-time work, has not been fully developed yet

3.6.2 Issues of the organisational structure

A certain level of progress for the organisational enhancement can be recognised as mentioned in 3.6.1. However, LMU engineers have pointed out the following issues since the beginning of the Previous Project.

- Lack of clear mandate of the LMU:

  There has been no legal framework for the LMU to perform their activities on slope disasters. The LMU engineers are limited in carrying out their duties and taking responsibilities on slope disasters because there is no mandate.

- Inappropriate scheme of services for the LMU engineers:

  The LMU engineers have been working voluntarily, particularly in emergency situations, which is beyond their scheme of services. For example, while the working hours of the engineers are defined as from 9 am to 4 pm under the scheme of services, the engineers must work at any time day or night if they are on call in emergency situations.

- Lack of qualification for the LMU engineers:

  Technologies of slope disasters have been transferred from the JET to the LMU engineers through the workshops, seminars and on-the-job training. However, the LMU engineers are not acknowledged as slope disaster experts by the government nor do they have appropriate qualifications. In other words, although the LMU engineers can support the JET and the JET's activities of the Project, they are not entitled to make decisions on slope disaster measures.

LMU/CES has addressed these issues to the MPI Head Office and has urged improvement of the situations at every opportunity. The JET has also supported solving the issues as these issues negatively affect the organisational structure enhancement as well as sustainability of the project outcomes.

However, due to the absence of an operational and legal framework of LMU and slow response by the MPI Head Office, the LMU has decided that all staff who worked as counterparts on the project were to be redeployed to a new design unit in the CES in the MPI in January 2017. The memorandum submitted from the director of CES to the Senior Chief Executive of the MPI clearly mentions that no personnel is posted to the LMU until the unit is legally supported (Appendix 3.6.1).

JET faced issues of no counterparts to conduct technical transfer to as well as the threat of unsustainability in the Project unless the organisational issues above were resolved.

3.6.3 Proposal of the setting up of the organisation

In order to solve the issues mentioned above, the JET organised a series of meetings and working sessions to discuss the organisational issues and solutions with the Minister, Permanent Secretary (PS), Deputy Permanent Secretary (DPS) and the other related officers in the MPI Head Office (HO). Table 3.5.2 is a summary of discussions on the organisational structure with the MPI HO.

Table 3.6.2 Discussions and achievements (Source: JET)

Date	Participants	Discussion points	Achievements
20/12/2016	DPS	• Mandate of the LMU • Recruitment of geotechnical engineers and geologists	• Increased MPI HO's understanding of current situation and issues of LMU
10/02/2017	DPS	• Sustainability of LMU and project achievements • Proper setting up of LMU or new organisation	• Increased HO's understanding of issues in which there are no engineers for LMU
14/02/2017	PS, Director of CES, Assistant PS, Office management assistant	• Information sharing with MPI HO about status of LMU • Discussion on setting up of Geotechnical Engineering Office and legislation	• Raised awareness on JET's problems in which there are no C/Ps for technical transfer • Increased understanding of LMU's status
27/02/2017	PS, DPS, Assistant PS, Office management assistant	• Information sharing about LMU's mandate prepared by MPI HO and organisational reform	• Clarified new organisational structure
09/03/2017	Minister, Senior advisor, PS, 2 DPSs, Director of CES	• Information sharing with Minister about LMU's issues and problem solving procedure • MPI's plan to establish GEO	• Clarified human resources and establishment procedure of new institution • Expedited the set-up of new organisation with the support of the Minister
10/03/2017	DPS, assistant	• Explanation of past projects, LMU's status and issues, and solution	• Increased understanding of the Projects and organisational issues
10/03/2017	Senior advisor	• Discussion of legislation process and organisational structure of GEO • Discussion of LMU's cooperation until GEO will be established	• Identified organisational structure of GEO
16/03/2017	DPS	• Discussion of MPI's plan about GEO's organisational structure, budget and human resources	• Identified organisational structure of GEO
22/08/2017	Director and Deputy director of CES	• Information sharing about status of LMU and GEO establishment	• Increased understanding of LMU's situation and establishing GEO
28/08/2017	Lead engineer of CES	• Information sharing about current works on slope disaster management	• Identified works by engineers in CES
30/08/2017	DPS. Director of CES	• Information sharing about status of establishing GEO	• Increased understanding of status of GEO
07/12/2017	2 DPSs, Director of CES and 4 MPI officers	• Information sharing about recruitment procedure • Finalisation of bidding documents for recruiting GEO director	• Identified necessary human resources for new organisation and recruitment procedure

Discussions hardly reached any conclusions at the beginning. The MPI and the JET had a series of meetings to identify the issues and consider solutions to make the organisation fully operational and enhance its organisational capacity. The minister of the MPI and the MPI management members have reached a conclusion to establish the Geotechnical Engineering Office (GEO) with the following details.

- Purpose of setting up the GEO

- To conduct slope disaster management by accredited professionals in geotechnical engineering and geology without the support of the JET after the Project

- To solve the constraints of qualification (one of the current issues is that the MPI engineers who support slope disaster management have a civil engineering background, whereas the experts with landslide background will be recruited for the GEO.)

- To widen responsibilities of slope disaster management

➢ Organisational structure

- GEO has two main sections. While the landslide section is responsible for landslide only, the geotechnical unit is responsible for the other slope disasters.

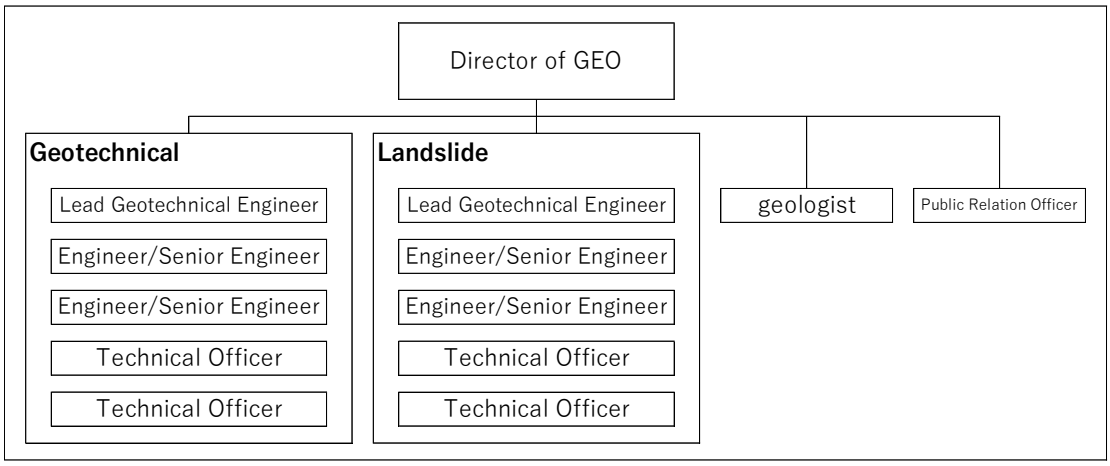


Figure 3.6.1 Proposed organisational structure (Source: JET)

- As the engineers currently working with the JET have strengthened technical capacity for slope disasters, the MPI allows them to transfer to the new organisation if they wish. These engineers support the qualified geotechnical engineering experts and geologist by utilising their technical knowledge obtained from the JICA Projects.

- GEO will be established at the same level of the CES in the MPI.

➢ Tasks and responsibilities of the GEO

- Management of landslide, slope failure, rock fall, debris flow, soil erosion.

- Carrying out geotechnical surveys and investigations, soil tests, zoning studies and slope disaster hazard mapping.

➢ Current recruitment status

- The MPI has initiated recruiting one geotechnical engineer and one geologist on a contract basis until the GEO is officially set up.

- As schemes of service, as well as all the conditions, including remuneration for Geotechnical engineer and geologist are finalised, recruitment is initiated through the Pay Research Bureau (PRB). The MPI is concerned that the conditions might not be

attractive to suitable candidates. In that case, the MPI will negotiate with the PRB to review the conditions.

- At the same time, the Expert Skills Scheme of the Ministry of Finance and Economic Development is considered to hire a director and lead engineers. The expert Skills Scheme offers better conditions than that of PRB. The MPI expects that the candidates with extensive knowledge and experience will apply.

- The budget for the public relations officer has been earmarked. As soon as the geotechnical engineer and geologist are recruited, the position of the public relations officer will also be advertised and the recruitment process will be started.

3.6.4 Technical workshop, working session and seminar

a. Kick-off workshop

a.1 Overview

The two-day workshop on 'Sendai disaster risk reduction framework and promotion of mainstreaming disaster risk reduction and reinforcement of quick response capacity' was organised on 10 and 11 February 2016. The main purpose of the workshop was to discuss the Project details with MPI and all the related stakeholders.

47 participants from 21 stakeholders participated in the first day of the workshop (attendance list is attached as Appendix 3.6.2). Followed by the opening remarks, lectures by Dr. Hitoshi Baba, Special adviser from JICA Tokyo, explained the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) and recommendations for the new Project as well as disaster response capacity enhancement. In addition, several presentations by the officers from Madagascar and Mauritius were given to share the disaster risk reduction activities in these countries.

The field excursion was scheduled on 11 February to share the outcomes of the Previous Project.

a.2 Outcome

On 10 February, followed by the opening remarks of the Honourable (Hon.) Mr. Bodha, Minister of MPI, Dr. Baba gave a lecture on the Sendai Framework and promotion of mainstreaming disaster risk reduction. However, a cyclone level 3 alert was declared for the whole island of Mauritius and an evacuation advisory was issued to all the participants of the seminar. The Seminar was terminated at 11 am. The field excursion was also cancelled.

Dr. Baba explained the outline of the Sendai Framework, seven targets and four priorities for action to prevent new and existing disaster risks to: (i) Understand disaster risk; (ii) Strengthen disaster risk governance to manage disaster risk; (iii) Invest in disaster reduction for resilience and; (iv) Enhance disaster preparedness for effective response, and 'Build Back Better' in recovery, rehabilitation and reconstruction.

Photo 3.6.1 Kick-off workshop (Source: JET)

b. Working session

b.1 Overview

The working session was organised on 13 June 2016 with the following aims:

- To introduce the activities of the Project;
- To reaffirm the mandate of the LMU among the related Ministries and Authorities;
- To identify the current situation and issues of the LMU;
- To reclarify the tasks of each stakeholder and understand the importance of cooperation among them; and

55 participants including minister of the MPI attended the session. Attendance list and programme are attached as Appendix 3.6.2.

b.2 Outcomes

- Hon. Mr. Bodha, Minister of MPI, emphasised the importance of slope disaster management in future in his opening speech. He also mentioned the activities conducted by the JET, LMU, and related stakeholders. According to his speech, small works such as the private house renovation plan should be managed by the local authorities, not by JET.
- Followings were discussed in order to establish a proper LMU:
  - LMU's mandate should be defined;
  - Appropriate resources such as personnel for the LMU are essential; and
  - Tasks and responsibilities of all the related stakeholders should be defined.
- The MPI Head Office submitted a letter to the Local Authorities about the shared responsibilities of slope disasters among the related stakeholders on the next day of the working session.
- The roles and tasks of the LMU were discussed in the session. This discussion was

highly important in order to define the mandate of the LMU in future.

- The roles of the JET in the Project was reemphasised as follows:

  - To develop a manual for slope disasters including slope failure, rockfall and debris flow;
  - To conduct technical transfer of slope disasters;
  - To define the responsibility of LMU and other stakeholders for slope disasters; and
  - To develop a mandate of the LMU as well as organising seminars and workshops in order to increase understanding of the responsibility of each stakeholder.


Photo 3.6.2 Working session (Source: JET)

c. Seminar

c.1 Overview

A seminar on slope disasters was held on 1 March 2017 in order to 1) provide technical transfer on slope failure, rock fall and debris flow; 2) share the efforts on slope disaster management by the related Ministries and Authorities; and 3) share the current situations and lessons learnt from the several project sites. 40 participants from 31 ministries and authorities attended the seminar (attendance list is as Appendix 3.6.2).

Followed by the opening speech by Mr. Jewon, Director of CES for the MPI and Mr. Ichikawa, Chief Adviser of the JET, an engineer from CES, JET and an officer from the NDRRMC conducted presentations. The discussion session was held in the afternoon in order to discuss the issues of slope disasters in each stakeholder.

The MPI Head Office was supposed to present the future organisational structure of landslide management, however the presentation was cancelled due to the absence of PS and DPS of the MPI. The seminar was concluded with the speech by Hon. Mr. Bodha, Minister of MPI (The programme is as Appendix 3.6.2).

c.2 Outcomes

- The Hon. Mr. Bodha, Minister of the MPI, emphasised the followings:

  - GEO will be established in the MPI. It is a full-fledged unit and address all the issues

relating to geotechnical survey, soil test and slope disaster management. It interfaces to all the related stakeholders. The unit consists of the existing engineers from the LMU and new employees. The MPI is currently setting up this unit and it is a transition period now. The LMU continues to follow up the countermeasure works in the slope disaster areas identified under the JICA project, however, a coordinating team is required for the new sites; and

- The slope disaster scheme which all the public in Mauritius is essential. In terms of cyclone, everyone understands the cyclone scheme and knows what to do in each stage of emergency. Mauritius needs a similar scheme for slope disasters.

➢ The MPI's organisational issues such as lack of mandate were shared and discussed with the related stakeholders. The stakeholders proposed several solutions to solve these issues.


Photo 3.6.3 Seminar (Source: JET)

d. Workshop/Seminar

d.1 Overview

A workshop/seminar on slope disasters was held on 6 December 2017 in order to 1) handover the manuals, guidelines and sensitisation materials to the MPI, 2) share the achievements and efforts on slope disaster management by the MPI and related stakeholders and 3) explain MPI's organisational plan for slope disaster management. Approximately 100 participants including the Minister of the MPI, Chief Representative of JICA Madagascar, Ambassador of Japan and other high delegates attended the opening ceremony. For the presentation session, 67 participants from 37 ministries and authorities attended (attendance list is as shown in Appendix 3.6.2).

The opening ceremony of the workshop/seminar commenced with a speech by Mr. Parbhunath, Director of CES for the MPI and Mr. Ichikawa, Chief Adviser of the JET. This was followed by the speech by Mr. Murakami, Chief Representative of JICA Madagascar as well as Hon. Bodha, Minister of the MPI. After this the opening ceremony was concluded by handing over of materials developed under the Project. There were nine presentations and Q&A session in the workshop/seminar. The programme is as shown in Appendix 3.6.2.

d.2 Outcomes

As a last occasion to meet all the related stakeholders in the Project, the workshop/seminar

provided a great opportunity to share the achievements, efforts and challenges to be tackled in the future. The outcomes observed from the presentations are summarised as follows:

- CES engineers fully understood the problems and conditions of the sites, and learnt what to do based on the technical transfer by the JET. They also emphasised the importance of cooperation among the related stakeholders, which is essential for the slope disaster management.

- Deputy Permanent Secretary of the MPI shared clear organisational structure of the GEO. The current set-up status was also mentioned.

- The related stakeholders shared what they have done for the slope disaster management of both hard countermeasures and soft countermeasures including community sensitisation activities. They also identified the issues and challenges, and considered future action plans.

- Manuals, guideline and sensitisation materials were explained. These materials will help the MPI and the other stakeholders to work in slope disaster management in the future without the support of the JET.

The workshop/seminar was covered by the media. The Minister of the MPI as well as a CES engineer were interviewed. The details are attached in Appendix 3.6.3.


Photo 3.6.4 Workshop/Seminar (Source: JET)

Chapter 4

Summary of technical transfer

4 Summary of technical transfer

4.1 General

One of the objectives of this Project is to upgrade the capacity of counterparts (C/P) to cope with the slope disasters such as rock falls, slope failures and debris flows. As the C/P have already grasped the basic concept of the landslide management during the Previous Project (including survey, monitoring analysis and countermeasure design and the site works at Chitrakoot), training under this Project involves small scale lectures, site investigations and reporting. At the same time, manuals of respective slope disasters are prepared for supporting sustainable knowledge and knowhow dissemination.

During the training under this Project, the C/P engineers did not seem motivated regarding the activities due to their views of the Ministry of Public Infrastructure and Land Transport (MPI) and lack of authority to make decisions with regard to the National Disaster Scheme published by National Disaster Risk Reduction and Management Centre (NDRRMC).

Although this is an internal issue of MPI, the Landslide Management Unit (LMU) members pointed out the following main issues:

- LMU members are employed under certain conditions (such as working hours of 9.00 to 16.00) which are the same as the other engineers. However, the LMU is forced to follow up on landslide issues whenever a disaster occurs without any consideration made for overtime hours, being on standby 24 hours a day;

- LMU members do not have any certificates nor registration in geotechnical engineering and thus they are not entitled to make decisions at the disaster site. These conditions are extremely difficult for them as making decisions at disaster sites is part of the responsibility of the engineers; and

- LMU members have no knowledge of slope disasters. Therefore, they cannot be obligated to support making the manual with the JICA Expert team (JET).

Unless these issues are resolved, the atmosphere and attitudes of C/P will not be as cooperative as has been the case in other disaster risk management projects conducted by JICA in various other countries. Therefore, JET decided to divide the issue into three parts: 1) Investigation of problematic slope disaster sites which is requested by the various stakeholders with C/P members; 2) After the inspection of the site, the report has been made to reflect the technical issues into the manual; 3) Support preparation of procurement protocol for the Chitrakoot Phase 2 countermeasure work; and 4) Visit MPI Head Office to ask for update on conditions to make performance on the project TOR easier for the C/P.

As mentioned in Chapter 3.5, since August 2017, the MPI and the JET had a series of meetings to identify issues and consider solutions to make the organization fully operational and enhance its capacity. The minister of the MPI and the MPI management members have reached a conclusion to establish the Geotechnical Engineering Office (GEO). Since then, the LMU and MPI have become fully involved and are cooperative on the ongoing issues. In this section, 1), 2) and 3) are described. Administrative issue 4) is summarised in Section 5.

4.2 Slope disaster site visits and reporting

Respective sites were visited and the type of the slope disaster was determined with the counterpart and reported. Major sites visited between January 2016 and December 2017 are summarised as follows:

Table 4.2.1 Site list by type of slope disasters (Source: JET)

Slope Disaster Type	Name of the sites (*)	Causes and Notes	Times Visited
Slope failure	1 Batelage	• Main causes of slope failure were rain and wind by cyclone in 2015 • Water from the houses influenced the slope stability	6
	10 Coromandel	• Rain water flowed down from the upper road, and it causes instability of the slope.	1
	11 Pitit Bel Air	• Part of the base of the slope was excavated by the land owner below the slope.	2
	12 Vallée Pitot	• Slope failure was caused by flash flood from the mountain slope and saturation of water in the filled material.	2
	13 Long Mountain	• Erosion of the slope was not caused by river water but from surface water from the house yard.	2
Rock fall and debris flow	2 Signal Mountain	• Rock fall, road settlement and debris flow in the 3km long road section	10
Slope failure and rock fall	4 Hermitage	• Artificially modified slope with the risk of slope failure. Cause of the slope failure was improper development.	1
Rock fall	3 Maconde	• Steep scarp along the B9 road. • Rock fall occurred frequently	6
	7 Ruisseau Créoles	• There are several boulders on the housing premises and in the slope behind.	3
River erosion and slope failure	8 Camp Garreau, Flacq	• The failure was caused by sewage water, rain water and river erosion.	1
	9 Kewal Nagar/Belle Rive	• The slope was created by river erosion and artificially modified slope	4
Landslide (no investigation)	5 Mount Ory	• District Council of Moka requested LMU to conduct an emergency investigation	3
	6 Mount Ory (Moka)	• District Council Moka requested LMU to carry out the survey of 'Application for the use of slope'.	1

* Name of the sites refers to Table 3.2.8.

Total sites visited together with LMU, JET and other stakeholders were 13. JET and LMU jointly investigated the sites as part of on-the-job training. The reports were compiled mainly by JET with the support of LMU. Still, the main actor shall be JET as the C/P clearly demonstrated their incompetence regarding technical background to make decisions. However, the routine was the same as the normal technical transfer in other similar types of JICA technical assistance.

4.3 Manuals

After the investigation, reporting and counterpart design are compiled. Each area was put into the investigation site record sheet with a serial number. Then the traditional phenomenon of the slope disaster was selected as the reference of the manual of slope failures, rock falls and debris flows developed under this Project. Some of the samples are figured out for use in the manual. As described in chapter 3, outline of the manual is shown in the following table:

Table 4.3.1 Contents of the manual of slope failures, rock falls and debris flows (Source: JET)

Chapter	Sub-Chapter
1 Introduction	1.1 What is landslide?
	1.2 Procedure manual of slope failures, rock falls and debris flows
	1.3 Explanation of technical terms
2 Surveys	2.1 Introduction
	2.2 Survey on slope failures
	2.3 Survey on rock falls
	2.4 Survey on debris flows
	2.5 Survey on drainage systems
	2.6 Survey on retaining wall and culvert
3 Design	3.1 Introduction
	3.2 Cut slopes
	3.3 Slope protection
	3.4 Countermeasures for rock falls
	3.5 Countermeasures for debris flows
	3.6 Drainage
	3.7 Retaining wall
	3.8 Culvert
4 Execution	4.1 Introduction
	4.2 Slope work
	4.3 Countermeasures for rock falls and debris flows
	4.4 Construction of retaining wall and culvert, etc.
5 Work Management and Inspection	5.1 Introduction
	5.2 Execution management
	5.3 Work inspection
6 Maintenance of Earth Structures	6.1 Introduction
	6.2 Maintenance of slopes
	6.3 Maintenance of drainage facilities
	6.4 Maintenance of retaining walls and culvert

The draft manual was developed by the end of March 2017, and the manual will be applied for the slope disaster sites during the Project period. The final version of the manual was published in December 2017.

Table 4.3.2 Contents of the revised landslide countermeasure manual (Source: JET)

0. Preface
0.1 Definition of landslides
0.2 Classification and mechanisms of landslides
0.3 Outline of landslides in Mauritius
1. Introduction
2. Survey and analysis
2.1 Landslide survey
2.2 Landslide monitoring
2.3 Landslide analysis
2.4 Basic factors and triggers (inducing factors) of landslides
2.5 Stability analysis
3. Landslide warning system
3.1 Introduction of landslide warning system
3.2 Landslide monitoring and warning
3.3 Emergency communication and evacuation
3.4 Landslide warning without instruments
4. Relocation support and compensation
4.1 Confirmation of the legal systems and schemes
4.2 Confirmation of the development restriction/land-use control
4.3 Basic concept of the hazard zone for development restriction
4.4 Confirmation of the proposed landslide prone areas and landslide hazard zones
4.5 Identification of the target areas for relocation and compensation
4.6 Implementation of the relocation
4.7 Implementation of the compensation
5. Information, Education, Communication (IEC)
5.1 Importance of IEC for landslide management
5.2 The main actors of the IEC activities for landslide management in Mauritius
5.3 Types of the IEC activities
6. Design for structural countermeasures
6.1 Principal of design for landslide countermeasures
6.2 Design of structural countermeasure works for landslide
7. Maintenance after installation of countermeasure works
7.1 Execution plan
7.2 Execution
7.3 Work management
7.4 Maintenance after installation of landslide countermeasure
7.5 Maintenance of existing structural countermeasure facilities
8. Initial survey and emergency response
8.1 General
8.2 Literature survey
8.3 Initial survey at site
8.4 Emergency response
8.5 Detailed survey plan

Table 4.3.3 Contents of the revised landslide countermeasure guideline (Source: JET)

0. Preface
0.1 Definition of landslides 0.2 Classification and mechanisms of landslides 0.3 Outline of landslides in Mauritius
1. Introduction
2. Literature survey
2.1 Data collection and its utilization 2.2 Confirmation of the legal systems/schemes and development restriction/land-use control
3. Initial survey at site
3.1 Setting of target landslide areas 3.2 Site survey and analysis
4. Emergency response
4.1 Structural countermeasure works 4.2 Evacuation and relocation support 4.3 Landslide warning systems
5. Detail survey plan
5.1 Outline of detail survey 5.2 Outline of countermeasure policy 5.3 Confirmation of development restriction/land-use control and legal systems/schemes

4.4 Countermeasure (Chitrakoot Phase 2 Site Works)

The Chitrakoot phase 2 site works were scheduled to commence in August 2016. Technical specifications were proposed at the time and the budget for 2016 (July 2016 - June 2017) was approved. However, due to the delay of the works such as bidding procedures, commencement of work was postponed to avoid the rainy season from December to April. The tendering was conducted in early February, and followed by the review of the documents along with the financial proposal. Although the final proposal was more than the ceiling price, the contractor and MPI reached a compromise.

The dry season is expected to begin in May; therefore, the commencement of the work was set for May 2017. Actual site work started in June 2017 after a land acquisition program by Ministry of Housing and Lands (MHL). As of December 2017, the work progress achieved 70% completion of the whole project. Supporting work of JET for MPI's administration and management were smoothly implemented for all kinds of countermeasure works to be conducted at the site.

Chapter 5

Issues identified

5 Issues identified

5.1 General

Major objectives of the Project operation can be classified into the two categories below (more specific issues, targets and current developments are tabulated in Table 3.5.1):

- Strengthening capacity of Landslide Management Unit (LMU) for disaster management of slope disasters
- Enhancing the ability to promote self-sustaining development

The first issue is much more about the LMU's legal frame work to create stress free working conditions for counterpart (C/P) engineers and motivate them to protect their country from slope disasters. Therefore, actions were taken by the Ministry of Public Infrastructure and Land Transport (MPI) Head Office to support LMU by taking the legal frame work (mandate) of LMU into consideration. The basic institutional frame work was suggested during the Previous Project as such that the recommendation of institutional arrangement and mandate of LMU. Therefore, JICA Expert Team (JET) repeatedly pushed MPI Head Office to promote proper assignment of registered engineers (geotechnical engineers) and preparation of the mandate of LMU since the beginning of the Project.

Second issue is about securing the sustainability of the slope disaster responsible body. This relates the basic background of LMU which leads the measures against the national policy. Therefore, the establishment of proper functional unit is the key issue of the Project.

These issues are matters of policy and of MPI administration, and are internal matters of MPI. Even the LMU made letters to improve the situations to the Senior Chief Executive (the top policy maker of public administration) who has not made any decisions yet. Unfortunately, due to the frequent change of the position of Permanent Secretary (PS) of MPI, these issues are not turn over properly to the successors.

However, in March 2017, Mr. Bundhooa, Deputy Permanent Secretary (DPS), was appointed as a 'C/P member' of the Project. Since then, JET visited his office to explain everything that had occurred during the past year regarding the Project.

Mr. Bundhooa promised JET to investigate the issues of this Project as well as to present JET with a draft paper of the 'mandate' and 'assignment of responsible engineers". In addition to the DPS being appointed, Mr Parbhunath, successor of Mr Jewon, was also appointed as director of Civil Engineering Section (CES). The importance of the issues in regard to the slope disaster were well recognised by the MPI at this stage

Under the Minister's leadership, with strong support by the newly appointed successors of MPI Head Office and CES, the mood of LMU has changed into one of cooperation to tackle the slope disaster issues. The needs of formulating an organisation to manage slope disaster (such as Geotechnical Engineering Office (GEO)) were well acknowledged and became one of the priority issues for MPI.

5.2 Solution of the Issues

5.2.1 Strengthening capacity of LMU for disaster management on slope disasters

Since January 2016, JET concentrated on supporting the establishment of a mandate and the assignment of responsible engineers. Until March 2017, JET held several meetings, joint discussions and seminars with all levels of MPI members including LMU, PS and DPS and the Honourable (Hon.) Minister of MPI.

On 14 February 2017, first meeting was held with Mr. Ragen, the newly appointed PS. There the explanation of the Project was made again with current issues to be solved. At the time the PS clearly stated the 'Civil Engineering Section and MPI Head Office will jointly prepare a cabinet paper (mandate) in 15 days to improve the situation of the LMU'. However, since then no response has been received or progress made on this issue.

Therefore, a meeting was urgently held with all policy makers on 9 March 2017. Together with the meeting with the Senior Advisor to the Minister held on 10 March 2017, the following decisions were made:

- C/P of JET is MPI (for most of the administrative issues) and LMU (for the technical aspects)
- A new office, GEO, will be established and some/all LMU members will be assigned to the office. The recruitment of geotechnical engineers is vital and is currently proceeding.
- Inside MPI, the same legal framework applies to all members. Therefore, there is no need to prepare a paper called a 'mandate' to be submitted to the cabinet.

JET was very anxious about the 'mandate' which has been followed up since 2015. Because of the lack of geotechnical background, no one knows how to formulate a proper plan for the setup of the new organisation; JET supported their activity to make Terms of Reference (TOR) of the new organisation (mandate), engineers' qualification and utilization of LMU members.

At the Seminar held in March 2017, the Minister made the following remarks;

- GEO will be established in the MPI. It is a full-fledged unit and will address all the issues relating to geotechnical surveys, soil tests and slope disaster management. It interfaces with all the related stakeholders. The unit consists of the existing engineers from the LMU and new employees. The MPI is currently setting up this unit and it is in a transition period now. The LMU continues to follow up the countermeasure works in the slope disaster areas identified under the JICA project; however, a coordinating team is required for the new sites; and
- A slope disaster scheme for all the public in Mauritius is essential. In terms of cyclones, everyone understands the cyclone scheme and knows what to do in each stage of emergency. Mauritius needs a similar scheme for slope disasters.

The institutional arrangement of GEO, with the utilization of LMU (and its know-how gained in the technical transfer), was raised as one of the priority issues in MPI.

On December 2017 the Workshop/Seminar was held (see Chapter 3.5.4). As a last occasion to meet all the related stakeholders in the Project, the workshop/seminar provided a great opportunity to share the achievements, efforts and challenges to be tackled in future. The outcomes observed from the presentations are summarised as follows:

- CES engineers fully understood the problems and conditions of the sites, and learnt what to do based on the technical transfer by the JET.
- Emphasised the importance of cooperation among the related stakeholders which is essential for the slope disaster management.
- Deputy Permanent Secretary of the MPI shared clear organisational structure of the GEO.
- The related stakeholders shared what they have done for the slope disaster management of both hard countermeasures and soft countermeasures including community sensitisation activities. They also identified the issues and challenges, and considered future action plans.

Manuals, guideline and sensitisation materials were explained. These materials will help the MPI and the other stakeholders to work for the slope disaster management in the future without the support of the JET.

5.2.2 Enhance the ability to promote self-sustaining development

The slope disaster management body will be under the transitional phase during the Project activity. Referring to the recent discussion, GEO will be the responsible body of MPI for the disaster management and will be functional within two years.

MPI is currently seeking geotechnical engineers to help establish and be assigned to the GEO. As some/all LMU members will be posted in this unit, hopefully the sustainability will be secured.

However, given the uncertainty of the time schedule for setting up the GEO, the JET decided to act with the LMU and continue the technical transfer and manual description.

JET supported all activities which relate to the strengthening of slope disaster management to enhance their capability, which will be the back bone of the GEO.

5.2.3 Other Progress

- Early warning system: The proposed system and plans to set it up are described in this report in Chapter 3.4.
- Planning Policy Guidance (PPG): Amended PPG 9 has been in effect since March 2016. It is planned to utilise the established Manuals in relation with the land management.
- Slope Disaster Preparedness Handbook and Leaflet: Public awareness and sensitisation materials covering four types of slope disasters were developed .

Chapter 6

Future directions

6 Future directions

The actions of JICA Expert Team (JET) on institutional strengthening of Landslide Management Unit (LMU) for the past year were made since these actions were recommended in the Previous Project. Still, there are number of uncertainties in the technical transfer and institutional strengthening of LMU, Ministry of Public Infrastructure and Land Transport (MPI).

Some of the important outcomes of the recent activities are as follows:

- Major policy makers and administrative staff jointly held a meeting and Hon. Minister gave clear direction to all, which was to set up the Geotechnical Engineering Office (GEO). LMU will also extend their knowledge into their activities. Most importantly, all the top MPI members shared information.

- Mr Bundhooa, Deputy Permanent Secretary (DPS), was appointed as a 'Counterpart of JET'; therefore, JET has a clear road map to make consultations about all administrative issues regarding MPI.

- Mr Parbhunath, Director of Civil Engineer Section, was appointed as the top management decision maker of LMU. He is prepared to provide full support for the establishment of GEO utilising LMU know-how and use/dissemination of the Manual

- Convenient sensitisation material 'Slope disaster preparedness handbook (English/French)' and 'Slope disaster preparedness leaflet (Creole)' was established by JET and GIS. A public relations officer will be recruited as soon as the GEO is established, and will be involved in the activities of sensitisation of both Public/Private organisations and local communities.

- MPI acknowledges the importance of slope disaster issues.

- MPI started to set up an organisation to tackle the issues on their own.

- MPI is highly motivated to cope with the issues for future activities against slope disasters.