ARAB REPUBLIC OF EGYPT

Academy of Scientific Research and Technology

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ALEXANDRIA

RÉPUBLIQUE FRANÇAISE

Centre National de la Recherche Scientifique and Office de la Recherche Scientifique et Technique Outre – Mer

Centre d'Etudes Phytosociologiques et Ecologiques L.Emberger

Ecothèque Méditerranéenne

MONTPELLIER

PARIS

AN ECOLOGICAL ASSESSMENT OF RENEWABLE RESOURCES FOR RURAL AGRICULTURAL DEVELOPMENT IN THE WESTERN MEDITERRANEAN COASTAL REGION OF EGYPT

CASE STUDY: EL OMAYED TEST-AREA

edited by

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1983

Published with the financial assistance of the French Ministry of Foreign Affairs and the staff and facilities of the Mapping Workshop of C.N.R.S./C.E.P.E.L. Emberger, Montpellier.

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TABLE OF CONTRIBUTORS

بسم الله الرحمن الرحيم

ملــــخص

منطقة الساحل الشمالى الغربى لمصر ما بين الاسكندرية والسلوم والتى تبلغ مساحتها مليون هكتار تمثل حاليا محورا هاما من محاور التنمية فى مصر . يتراوح المتوسط السنوى لكمية الأمطار بهذه المنطقة بين ١٠٠ و ١٨٠ مم ، وتتناقص هذه الكمية سريعا من الساحل إلى الداخل . والغطاء النباتى فى الغالب من طراز الإستبس ويتنوع باختلاف التضاريس وخصائص التربة والموارد المائية وإستخدام الأرض . ولقد بلغ تدهور البيئة بهذه المنطقة نتيجة للرعى الجائر وإقتلاع النباتات وحرث الأرض وأنشطة الانسان الأخرى درجة تدعو بإلحاح إلى إتباع سياسة رشيدة فى إدارة وإستغلال مواردها .ولا يستهدف هذا الكتاب إقتراح هيكل محدد لمثل هذه السياسة ، ولكنه يعرض طريقة لجمع وعرض البيانات اللازمة التى قد تساعد على تفهم مشاكل البيئة بالمنطقة والتى قد تعين فى التخطيط لهذه السياسة ،ثم يعرض تطبيقا عمليا لهذه الطريقة بمنطقة إختبار مساحتها ٥٠٠٠ هكتار .

يبدأ الكتاب بخلفية موجزة عن مشروعى سامدين ورمدين ، ومقدمة عن دور الخرائط كأداة لمسح الموارد الأرضية . ويشمل الجزء الأول بيانا بأهداف العمل الذى يتضمنه هذا الكتاب ووسائل التعبير عن البحوث والدراسات الحقليه المتكاملة بالأخذ فى الإعتبار المقياس الذى تجرى به هذه الدراسات ، ونوعية الوثائق التى يرجى إعدادها ، والمتغيرات والقياسات المطلوب رصدها للتعبير عن التنوع فى الخصائص البيئية بمنطقة الدراسة تعبيرا دقيقا .

ويتناول الجزء الثانى نتائج الدراسة بمنطقة العميد ، كمنطقة إختبار تمثل الجزء الشرقى من الساحل الشمالى الغربى لمصر . وقد أعدت معظم الخرائط التى يتضمنها هذا الجزء بمقياس ١ : ٥٠٠٠٠ ، إلا أن خرائط التطبيق الحقلى أعدت مبدئيا بمقياس ١ :٢٥٠٠٠ ، وهو المقياس الشائع للصور الجوية التى إلتقطت لهذه المنطقة ، ويعرض هذا الجزء كذلك أهم الخصائص البيئية فى الوقت الحاضر بكل من

الوحدات الطبوغرافية (التى تمثل بيئات مختلفة) فيما يتصل بالمناخ والموارد البيئية والتربة (خريطة ملونة) وإستخدام الأرض والغطاء النباتى (خريطة ملونة للغطاء النباتى وأخرى غير ملونة للبيئة النباتية) والإنسان ونظمه الإجتماعية والإقتصادية (خريطة ملونة لتوزيع القبائل وتحت القبائل ، وأخرى غير ملونة لتوزيع المستوطنات وبنيتها الأساسية) • ويتناول هذا الجزء كذلك نفس الخصائص البيئية فيما يتعلق بتأثرها بأنشطة الانسان ، وذلك بتحليل التغيرات فى إستخدام الأرض التى حدثت خلال الفترة بين عامى ١٩٥٤ و ١٩٧٩ ، والتغيرات المحتمل حدوثها فى المستقبل فى كل من الوحدات الطبوغرافية • وبمعرفة أى العوامل أكثر تأثيرا فى تدهور الأرض بالمنطقة وأى البيئات أكثر حساسية لتأثير تلك العوامل ، أمكن أيضا تحديد المدى الحالى والمدى المحتمل لحساسية كل من هذه البيئات ،وذلك بالأخذ فى الإعتبار قابليتها للتدهور ومدى رغبة الانسان فى إستغلالها • ويتضمن هذا الجزء خريطة ملونة تبين نتائج هذا التحليل وتشمل وصفا موجزا لعمليات التدهور الحالية والعوامل التى تؤدى إليها •

ويعرض الجزء الثانى كذلك تقييما للموارد البيئية بالوحدات الطبوغرافية المختلفة وأنماط إستغلالها الحالية • وملحق بهذا التقييم خريطة ملونة تشمل تقديرات لبعض موارد الأرض والنباتات •

ويتناول الباب الأخير من هذا الجزء إقتراحات لبعض السياسات التى يمكن تطبيقها فى إدارة هذه الموارد ، والعواقب التى يمكن أن تنجم عن ذلك ، ولصانعى القرارات والمخططين أن يتخيروا المستوى الملائم من إستخدام الأرض تبعا لقدرات البيئة وواقعها الإجتماعى (قوى العمالة والإستثمار ومتطلبات السكان) على بصيرة من عواقب ذلك الإختيار • وتشمل هذه الإقتراحات خمس مستويات من كثافة إستخدام الأرض • فى المستويين الأول والثانى تقل كثافة إستخدام الأرض عن المستوى الثالث وهو المستوى السائد حاليا بالمنطقة ، وفى المستوى الرابع يزداد نشاط الإنسان فى إستخدام الأرض ، ويبلغ أقصاه فى المستوى الخامس حيث يتم رى الأرض بمياه النيل • ولندرة المعلومات عن معدل تحول أى من الوحدات البيئية من صورة إلى أخرى فى كل من مستويات إستخدام الأرض ، لم يمكن حساب مدى التغيرات التى قد تحدث

فى صفاتها أو فى مواردها • وعلى ذلك فإننا نورد هنا تقديرات لما قد يحـدث بناء على مدى قابلية الأرض للتدهور فى كل من الوحدات البيئية وعلى مـــدى رغبة الإنسان فى إستغلالها •

ويختتم الجزء الثالث والأخير هذا الكتاب بأهم الإستنتاجات والتوصيات الـتى نرجو أن تسهم فى تخطيط سياسة رشيدة لإدارة وإستخدام موارد البيئة بمنطقـة الساحل الشمالى الغربى لمصـــر •

بسم الله الرحمن الرحيم

قائمة الجداول والأشكال

بسم الله الرحمن الرحيم

الاستنتاجات والتوصيات

تمثل مجموعة الخرائط المتكاملة لمنطقة الساحل الشمالى الغربى لمصر التى يتضمنها هذا الكتاب عملا علميا فريدا فى بحوث الصحارى التى يتجه إليها الإهتمام كمحاور جديدة للتنمية الإجتماعية والإقتصادية فى مصر ، هو عمل فريد فى أسلوبه العلمى المتكامل ، فريد فى طريقة عرضه الأكثر ملائمة لصانعى القرار ، فريد فى تحليله المتعمق للتغيرات التى تطرأ على مكونات البيئة بتأثير الأنماط الحالية لإستخدام الأرض • وهذا العمل ليس بأى حال أقصى ما كان يأمل المشاركون فى هذا الكتاب تحقيقه ، فبعض المتغيرات لم تدرس والبعض الآخر تم تناوله دون تعمق نظرا لندرة المعلومات عنها أو عدم توافر سبل رصدها ، إلا أنه يعتبر مثالا لعمل علمى يستحق المتابعة والإمتداد •

الدروس المستفادة من هذا العمل عديدة ، والخبرة التى إكتسبها المشاركون فيه تهيئ لهم خلفية تؤهلهم لطرح بعض التوصيات واستخلاص بعض الاستنتاجات التى يرون أنها قد تفيد فى التخطيط لدراسات مماثلة وفى الإعداد لسياسة رشيدة فى إدارة وإستغلال موارد البيئة بمنطقة الساحل الشمالى الغربى لمصر • بعض هذه الإستنتاجات والتوصيات صادر عن الخبرة التى إكتسبها المشاركون فى هذا العمل ، وهذه ذات طبيعة شمولية تسرى على منطقة الساحل الشمالى الغربى ، والبعض الآخر يعتمد على البيانات التى تم رصدها وتمثيلها فى الخرائط التى يتضمنها هذا الكتاب ، وهذه تقتصر على منطقة العميد والمناطق التى تماثلها فى الخصائص البيئية والاجتماعية :

(١) تعتبر خرائط توزيع النظم البيئية وأنماط إستخدام الأرض أداة فعالة من أدوات بحوث تركيب مكونات البيئة ، وهى إحدى ثلاثة إتجاهات رئيسية لبرامج البحوث التى تستهدف زيادة القدرة على تنمية موارد البيئة ، والإتجاهين الآخرين هما بحوث العمليات البيئية والبحوث التطبيقية • وبينما تهتم بحوث العمليات بدور كل من مكونات البيئة ، وتهتم البحوث التطبيقية بأساليب التقنية فى إستغلال وإدارة الموارد ، فإن بحوث تركيب مكونات البيئة تهتم بتوزيع النظم البيئية والأنواع النباتية والحيوانية •

وبحوث تركيب المكونات البيئية لازمة لإرساء قاعدة عريضة من المعلومات تمكن من تقييم موارد البيئة والقدرة على إستغلالها • والخرائط التى يتضمنها هذا الكتاب لطبيعة الأرض وطبوغرافيتها ولخصائص ومصادر المياه بمنطقة العميد يمكن أن تسهم فى تقييم الموارد المائية وفى الوسائل الرشيدة لصونها وإستغلالها • غير أن المعلومات المتاحة عن أحد المصادر الرئيسية للمياه بالمنطقة ـ وهو الماء السطحى قليلة ، ولا يمكن تقدير كمية هذا الماء من أرصاد المناخ لأنها حصيلة لعديد من العوامل مثل معدل الأمطار وقدرة التربة على التشرب والتغيرات الدقيقة فى طبغرافية الأرض ونوعية الغطاء النباتى والمحتوى الرطوبى لطبقات الأرض السطحية • ويتحتم دراسة تأثير هذه العوامل على كمية الماء السطحى بتعمق ، كما يتحتم إعداد خرائط تفصيلية عن التغيرات الدقيقة فى طبغرافية الأرض حتى يمكن تقدير هذه الكمية وتبين وسائل صيانتها وإستغلالها • ومن الضرورى كذلك الإستفادة من مزايا الوسائل القديمة لصيانة الموارد المائية (كالخزانات الأرضية والكروم) وتهيئتها للإستغلال الأمثل لهذا المورد الهام من الموارد المائية بمنطقة الساحل الشمالى الغربى •

(٢) تحدث تغيرات فى النظم البيئية مع الوقت بتأثير العوامل الطبيعية وبفعل الإنسان ،ورصد هذه التغيرات ضرورى حتى يتسنى إقتراح سياسات بديلة لإستخدام الموارد البيئية تتفادى العواقب الضارة لتلك التغيرات • ومن أبرز التغيرات غير المرغوب فيها بمنطقة الساحل الشمالى الغربى هى تعرية التربة بواسطة الماء السطحى وسفى الرمال بواسطة الرياح نتيجة للرعى الجائر والإسراف فى زراعة المحاصيل الحولية • ولا يحق لنا أن ننحى باللائمة لمثل هذا الإستخدام غير الرشيد على الرعاة أو الزراع ، إذ أنهم يقومون بذلك لسد حاجاتهم المعيشية دون وعى بالعواقب ، خصوصا على المدى البعيد • ومن الأجدى أن تجرى تجارب حقلية تشرح لهم وسائل بديلة تعينهم على كيفية تجنب التأثيرات الضارة لإستخدام الأرض •

(٣) يجب عند التخطيط لمستقبل التنمية بالمنطقة أن تراعى الظروف المعيشية وواقع الحياة بها • فبدلا من فرض نظم زراعية واقتصادية ضخمة لا تتوائم مع المتغيرات

البيئية والإجتماعية ، قد يكون من الأجدى أن تستهدف خطط التنمية نظما زراعية محدودة وصناعات ريفية صغيرة بإستخدام الموارد المتاحة بالمنطقة ، وبإتباع الوسائل البسيطة لصون الماء والحفاظ على التربة ، وإستغلال مصادر الطاقة التى تعتمد على الموارد المحلية المتجددة (كالطاقة الشمسية والبيوجاز) ٠

(٤) إن الاعتماد على إستراتيجية متكاملة تشمل نظما متعددة من إستخدام الأرض يوفر عائدا أكثر ضمانا لإقتصاد الكفاف ويرسى قاعدة أصلب لإقتصاد السوق ، لذلك فإنه يكون من الأجدى الإعتماد على مجموعة متكاملة من نظم الإنتاج (مثل المراعى والزراعة المطرية للمحاصيل وأشجار الفاكهة والصناعات المحلية) بمنطقة العميد والمناطق الأخرى المماثلة ، وذلك بالتكامل مع نظم الزراعة المروية بالمنطقة الشرقية ٠ هذا التكامل ذو فائدة فى تهيئة غذاء إضافى لحيوانات الرعى ـ اذا ما إستغل جزء من المساحات المروية فى زراعة بعض محاصيل العلف خصوصا فى فصل الجفاف وفى بداية فصل النمو ٠ وبهذا تتهيئ الفرصة الملائمة للغطاء النباتى الطبيعى ليستعيد كفاءته فى النمو ولينتج قدرا أكثر من العلف لحيوانات الرعى ، بالإضافة إلى أن ذلك يوفر على الرعاة وحيوانات الرعى الصعوبات الناجمة عن رحلتها السنوية إلى وادى النيل طلبا للمزيد من العلف ، ويجنبهم مخاطر جلب الأمراض الحيوانية إلى المنطقة ٠

(٥) ينمو النظام البيئى طبيعيا إذا ما ترك دون تدخل حتى يصل إلى طور الذروة ٠ فى هذا الطور يكتسب النظام البيئى نوعا من التوازن بين المكونات الحية ـ خاصة الغطاء النباتى ـ والظروف البيئية الطبيعية ، ويؤدى به ذلك إلى حالة من الإستقرار النسبى وإلى أقصى مقدرة على إستيعاب إضافات من الطاقة والعناصر ، وبالتالى إلى إنتاج أقصى قدر من الكتلة الحية وإكتساب الحماية من تقلبات الظروف البيئية ٠ والنظم البيئية الجافة ـ كما فى منطقة العميد ذات تركيب بسيط بشكل عام حتى فى طور الذروة ، وعلى ذلك فإنها غالبا ما تكون على قدر بسيط من الإستقرار ومن المقدرة على الحماية ، وبالتالى أكثر عرضة للتدهور من النظم البيئية الأخرى ، على أن النظم الجافة إذا تركت دون تدخل من جانب الانسان ، فإنها عادة ما يمكنها أن تستعيد مع الوقت توازنها وقدرتها على الحماية فى أعقاب التقلبات البيئية

(مثل نوبات الجفاف الحادة) • أما التقلبات التى تحدث بفعل الانسان (نتيجة للرعى الجائر والإسراف فى زراعة المحاصيل الجافة على سبيل المثال) غالبا ما تزيد فى تبسيط تركيب النظم الجافة مما ينتج عنه الإقلال من قدرتها على الإستقرار ومن إنتاج الكتلة الحية التى تكسبها القدرة على الحماية ، وبالتالى تكون أكثر عرضة للتدهور • وكما يتضح من البيانات التى يتضمنها هذا الكتاب فإن النظم البيئية بالساحل الشمالى الغربى لمصر قد تدهورت بدرجات متفاوتة ، ولكى تستعيد هذه النظم قدرا معقولا من كتلتها الحية التى توفر لها الحماية من التقلبات البيئية ، فإن سياسة إستخدام الأرض يجب أن تستهدف محاكاة تركيب تلك النظم فى طور الذروة • وقد ذكر فى باب ديناميكية الغطاء النباتى من هذا الكتاب (٣ـ١ـ٤ـ٣) أن مجتمعات الذروة بالساحل الشمالى الغربى لمصر لا يمكن تحديدها على وجه اليقين، ولكن نظرا لسيادة الأنواع الشجيرية ووجود مخلفات من البعض الآخر ، فإنه أمكن إفتراض أن الغطاء النباتى الحالى ما هو إلا طراز تخلف عن تدهور نوع من الغطاء الشجيرى الذى تسوده أنواع الزيتون والخروب • لهذا فإننا نوصى بالعمل على التوسع فى أنواع من هذه الأشجار وغيرها من أشجار الفاكهة التى تتحمل الجفاف ، وبذلك فإنه يمكن محاكاة طور الذروة الذى يكفل أقصى إنتاجية وحماية ممكنة • ومن ناحية أخرى ، قد لا يكون من الصواب منع الرعى الجائر وإقتلاع النباتات والإسراف فى زراعة المحاصيل الحولية دون طرح بدائل لهذه الأنشطة • لهذا فإن بعض هذه الأشجار والشجيرات يجب أن يكون صالحا كمصدات للرياح والبعض الآخر صالحا لإنتاج العلف لحيوانات الرعى والأخشاب اللازمة للوقود ، وبهذا فإنه يمكن مقابلة إحتياجات السكان وتخفيف الضغط الرعوى عن الغطاء النباتى الطبيعى الذى يمكنه عندئذ أن يستعيد مع الوقت قدرته القصوى على الإنتاج وحماية التربة من التعرية بالمياه السطحية والرياح وزيادة قدرتها على التشرب والإحتفاظ بالماء •

(٦) يجب أن تجرى تجارب بالمنطقة لاختبار مدى كفاءة المحاصيل سواء كانت محلية أو مستوردة فى إستخدام المياه ، ولإختبار تأثير الأسمدة العضوية وقوام التربة

و ملوحتها على نمو تلك المحاصيل ، و ذلك قبل التوسع فى زراعتها لإختيار أكثرها تكيفا لظروف البيئة و أغزرها إنتاجية • على أنه يجب مراعاة أن التوسع فى زراعة الأنواع المستوردة عالية الانتاج قد يهدد وجود الأنواع المحلية الأكثر تحملا لظروف البيئة • هذه الأنواع المحلية قد تكون ذات أهمية قصوى فى صون الأنواع العالية الانتاج والأكثر عرضة للاصابة بالأمراض و للتقلبات الحادة فى الظروف البيئية • و على ذلك فإن الفائدة المرجوة من الأنواع عالية الإنتاج يجب أن تدعم و تستكمل عن طريق برامج للتهجين لتنمية و صيانة صفات المقاومة و التكيف ، و الأنواع المحلية قد تكون لازمة لتحقيق مثل هذا الهدف إذ أنها بالتعرض لظروف المنطقة لقرون عديدة إكتسبت مع الوقت صفات وراثية تؤهلها للتكيف لهذه الظروف ، مثل هذه الصفات يمكن نقلها إلى المحاصيل المستوردة ذات الإنتاجية العالية • و نوصى كذلك باجراء تجارب حقلية لزيادة الرصيد من بذور النباتات المحلية ذات القيمة الرعوية العالية • والتى تتهدد بالإندثار نتيجة للرعى الجائر الذى ساد المنطقة لقرون عديدة ، كما ننصح بحماية بعض المساحات الصغيرة من الرعى و إقتلاع النباتات ، و ذلك لتهيئة الفرصة لتلك النباتات للتكاثر و زيادة رصيدها من البذور • و من المرغوب فيه أيضا إجراء تجارب عن طرائق بديلة لفلاحة الأرض و الدورات الزراعية لمقارنتها بما هو متبع حاليا •

(٧) تتميز تربة النظم البيئية بالساحل الشمالى الغربى لمصر بمحتواها العالى من كربونات الكالسيوم مما ينعكس على المحتوى الزائد عن المعدل من الكالسيوم فى نباتات الرعى • و التخلص من هذه الزيادة يمثل عبئا على حيوانات الرعى • لهذا فإنه يجب إجراء دراسة للتعرف على أنسب السبل لخفض معدل إمتصاص الكالسيوم فى أمعاء الحيوانات عن طريق زيادة محتوى البوتاسيوم فى غذائها و ضبط نسبة الكالسيوم إلى البوتاسيوم فى غذائها فى الحدود المناسبة (١ : ٢ أو ٣) •

(٨) لعل من أهم ما أدت اليه الزراعات المروية المكثفة شرقى العميد هو التحول السريع من إقتصاد الكفاف الى إقتصاد السوق ، و بذلك فإن إقتصاد منطقة الساحل الشمالى الغربى و خاصة مناطق الإستصلاح الزراعى ، أصبح أكثر إرتباطا ببنية الإقتصاد القومى ، و قد كان لذلك تأثير على الهيكل الإجتماعى و الإقتصادى للمنطقة من الواجب تقييمه • فإن خطة التنمية الريفية بالمناطق المروية على سبيل المثال تعتمد أساسا على

قوى العمالة بالمناطق الأخرى ، ولهذا فإنه من الأفضل أن تكون هذه الخطة متكاملة بحيث لا يقتصر توجيه العمالة إلى المناطق المروية ولكن أيضا إلى أنشطة أخرى ذات أهمية إجتماعية للمنطقة بأسرها ، مثل تربية الحيوان والصناعات البيئية والسياحة •

(٩) يتضح من الإستخلاصات السابقة أن الحاجة ملحة إلى المزيد من النشاط البحثى بالمنطقة وإلى المزيد من العمل من جانب صانعى القرار ومنفذى خطط التنمية لرسم سياسات لإستخدام الأرض تضمن مستوى عال من الإنتاج ،وتضمن فى ذات الوقت درجة عالية من التناسق بين المتغيرات البيئية والتقنيةوالاجتماعية ، ويتطلب ذلك تسهيلات لمتابعة البحوث عن تركيب وعمليات النظم البيئية والتى بدأت فى مشروعى سامدين ورمدين ، وكذلك البدء فى البحوث التطبيقية ، كإجراء التجارب الحقلية لإختيار خطط إستخدام الارض (كخطة للتكامل بين زراعة الشعير وتربية الحيوان وزراعة الأشجار) والطرائق الحديثة فى إجرائها ، ولرصد الآثار التى قد تنجم عنها • ويحتاج منفذى خطط التنمية دعما لتنفيذ هذه الخطط كإمدادهم بما يحتاجونه من المعدات اللازمة لفلاحة الأرض وإنشاء صناعات بيئية صغيرة ،وإمدادهم بالبذور وشتلات الأشجار والشجيرات ، وتزويدهم بالإرشادات لإستخدامها • وهناك ايضا حاجة ملحة لسد الفجوة بين الباحثين العلميين وصانعى القرار ومنفذى خطط التنمية ، حتى يمكن للباحثين التعرف على أولويات البحوث اللازمة لتزويد خطط التنمية بالمعلومات ، وحتى يمكن لصانعى القرار ومنفذى خطط التنمية تفهم العواقب البيئية التى تنجم عن تطبيق خططهم • وعلى ذلك فإنه من الواجب إنشاء قنوات إتصال بين الجهات الحكومية المعنية وسكان المنطقة ومعاهد البحوث ، وتنظيم لقاءات وحلقات تدريب دورية لتحقيق هذه الأهداف •

RÉSUMÉ

La région cotière nord-ouest de l'EGYPTE qui s'étend sur environ 1 000 000 ha est située entre les isohyètes 180 mm (Alexandrie) et 100mm (Sollum) avec une décroissance rapide des précipitations du rivage vers le plateau intérieur.

La végétation de cette région est essentiellement steppique et les principaux types sont en relation avec la physiographie, l'hydrologie, les sols et les conditions d'utilisation du sol.

Progressivement dégradé (surpâturage, éradication des ligneux, labours, autres pratiques telles que l'extraction de calcaire ...) le milieu devrait faire l'objet d'un aménagement urgent et si possible rationnel. Si une telle proposition n'est pas totalement étudiée ici, nous tentons cependant de fournir une méthode de collecte et de présentation des données de base nécessaires pour une bonne compréhension des problèmes dans une telle région et utiles pour les planificateurs. Une application est proposée pour une zone-test de 5 000 ha.

A la suite d'une brève présentation des acquis des projets SAMDENE et REMDENE et une introduction relative à l'intérêt de la cartographie pour des inventaires de ressources terrestres, la première partie offre un aperçu des objectifs de ce document et de la manière d'exprimer les résultats des recherches intégrées de terrain par le choix de l'échelle de travail, des divers documents à établir, des facteurs à relever et des mesures à effectuer sur le terrain pour atteindre une bonne représentativité régionale.

La seconde partie concerne l'étude de cas d'El Omayèd. Cette zone-test est une portion représentative d'une partie du "désert côtier du nord-ouest". Quasiment toutes les cartes sont élaborées à l'échelle 1 : 50 000 alors que les minutes de terrain sont dressées au 1 : 25 000 qui est l'échelle la plus courante des photographies aériennes de la région. Sont ainsi présentées successivement sur la base du découpage physiographique les principaux paramètres écologiques dans leur état présent : climatologie, hydrologie, sols (1 carte couleur), occupation des terres et végétation (1 carte couleur pour l'occupation des terres, 1 carte noir et blanc pour la phyto-écologie), l'homme et les systèmes socio-économiques (1 carte couleur de répartition des sous-tribus, 1 carte noir et blanc pour la répartition des établissements humains et l'infrastructure, toutes deux à l'échelle 1 : 71 000).

Le chapitre suivant est relatif à l'évolution des mêmes paramètres en fonction des changements dans la pression humaine évaluée au travers d'une analyse de l'évolution de l'utilisation du sol entre 1954 et 1979 pour chacune des unités physiographiques.

Cette étude, de l'évolution des conditions du milieu dans le proche passé, est complétée par un aperçu sur l'évolution future possible. Les facteurs actifs dans la dégradation sont connus, comme est connu également le fait que les divers types de milieux sont plus ou moins sensibles à l'action de ces facteurs. Cette connaissance nous conduit à une analyse de la sensibilité (potentielle et présente) des diverses unités physiographiques en prenant en compte les notions de vulnérabilité et d'attractivité. Une carte en couleur a été établie sur ce thème et il est également proposé une description des facteurs et des processus, les plus fréquents, de la détérioration de l'environnement.

Des évaluations et des mesures des ressources ont aussi été faites pour les diverses unités physiographiques. Les ressources sont caractérisées par leur état présent, leur utilisation et leurs potentialités. Des cartes en couleur ont été établies pour les ressources en sols, les ressources végétales et la capacité de charge.

Le but du cinquième chapitre de cette seconde partie est de proposer quelques réflexions à propos de divers scénarios possibles d'aménagement des ressources terrestres et de leurs conséquences. De fait, le planificateur devrait choisir un niveau d'intensité d'utilisation du sol en tenant compte des potentialités de la zone, des offres (force de travail, finance) et des besoins sociaux. Les scientifiques doivent avertir les planificateurs des conséquences de leurs choix. Cinq niveaux d'intensité d'utilisation des terres ont été définis. Aux niveaux 1 et 2 la pression humaine est réduite par rapport aux conditions actuelles d'utilisation (qui est le niveau 3). Au niveau 4 l'intensité humaine est accrue et il en est de même au niveau 5 avec l'introduction de l'irrigation. Du fait du manque de données concernant la vitesse de transformation d'une unité en une autre dans les différentes hypothèses examinées, il n'a pas été possible de calculer l'évolution des surfaces et des productions. Nous nous contentons donc de fournir une estimation du devenir de la zone pour les diverses classes d'attractivité et de vulnérabilité.

L'ensemble des chercheurs impliqués dans cette étude ont tenu à exprimer dans la troisième partie de ce document leurs recommandations pour un aménagement de l'espace rural conçu sur des bases écologiques.

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Liste des Figures et des Tableaux

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SUMMARY

The western coastal region of EGYPT which covers about 1,000 000 ha lies between isohyetes 180 mm (Alexandria) and 100 mm (Sollum) with a rapid decrease in the amount of rainfall from the seashore inland.

Vegetation in the region is mainly steppic and the main types are related to the physiographic, hydrologic, edaphologic and land-use conditions and characteristics.

The environment being gradually deteriorated (by overgrazing, uprooting, ploughing and other practices as quarrying ...) requires an urgent and, if possible, sound management. Although a sound management plan is not completely proposed here after we, however try to present a method for gathering and presenting basic data which are required for a good understanding of the problems in such region and which may prove useful for planners. An application is given for a test-area of 5,000 ha.

After a brief presentation of the background of SAMDENE and REMDENE projects and an introduction about the role of mapping as a tool for land resources surveys, Part I gives an outline of the objectives of this document, and of the means to provide an expression of integrated field research considering the choice of the scale to undertake the study, the kind of documents to establish, the factors to check and the measurements to undertake in the field for a good regional sampling.

Part II deals with the case study of El Omayed. This test-area is a representative portion of a part of the "western coastal desert". Most of the maps are elaborated on the scale of 1 : 50,000, but for the field execution map drafts were established on the scale of 1 : 25,000 which is the common scale of the aerial photographs in this area. The main ecological features at present based on a classification of physiographic units are then successively presented : climatology, hydrology, soil (1 colored map), land use and plant cover (1 colored map for land cover, 1 black and white map for phyto-ecology), human and socio-economic systems (1 color map for sub-tribes distribution, 1 black and white map for distribution of human settlements and infrastructure both at the scale 1 : 71,000).

The following chapter deals with the evolution of the same main ecological conditions according to the changes in human pressure assessed through an analysis of the land-use evolution from 1954 to 1979 and considering the various physiographic units.

The treatment of the evolution of environmental conditions is partly completed by a quick look at the possible evolution in the future. Active factors on the degradation are known, and it is also well known that different types of environment are more or less sensitive to these factors. Such understanding leads to an analysis of the sensitivity (potential and present) of the various physiographic units taking into account such notions as vulnerability and attractivity. A color map is also established and a description of current environmental deterioration processes and factors is given.

Various resources of the different physiographic units have also been assessed or measured ; they are successively treated in their present status, as to their utilization and potentialities. A color map is established for some of them (potential land resources, plant resources, carrying capacity).

The main objectives of the fifth chapter of Part II is to propose some thoughts about various scenarios for the management of land resources and their consequences. Ultimately, the planner should have to choose a level of land-use intensity according to the potentialities of the area and to the social realities (labour force, money and population requirements). The scientists have to warn the planner about the consequences of his choice. Five levels of land-use activity are defined and their consequences examined. For levels 1 and 2, human pressure is decreased in regard to the present practices (which is level 3). For the level 4 the human activity is increasing, as it is also the case for level 5 for which irrigation is concerned. Taking into account the lack of data about the speed of transformation of one unit to another for different hypothesis of land-use it was not possible here to define the evolution of the areas and of the resources only by automatic computation. We are just giving estimations of what could happens in terms of percentage of the area for the different classes of attractivity and vulnerability.

Conclusions and recommendations from scientists involved in this publications are expressed in Part III.

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List of Figures and Tables

TABLE OF CONTENTS

***

INTRODUCTION

a) Background of SAMDENE[*] and REMDENE[**] Projects

by Mohamed, A. AYYAD

An environmental management policy can be successful only if it is formulated with a basic understanding of the full complexity of the ecosystem : its structure and function, a knowledge of its properties (in particular the properties of stability and resilience), and a consideration of the history of manipulations and perturbations that have induced changes in its components. If, for whatever pragmatic reasons any of these criteria is ignored, there should be full appreciation of the consequences on environmental qualities. This is particularly true with arid and semi-arid ecosystems which are fragile and low stability and resilience. These ecosystems have limited carrying capacities : limited potentials of material cycling and energy flow, and limited abilities to absorb changes. If land-use practices exceed the carrying capacity of an ecosystem, the dynamic balance that gives it apparent stability will be upset and the ecosystem functioning will be impaired, and damage in the form of soil erosion, salinization, outbreaks in phytophagous insects, rodents, and weeds ... etc., may be irreparable.

The activities of the SAMDENE project have been directed since its initiation in 1974 towards the fulfillment of the above criteria, in order to lay a scientific basis that could be utilised in future management plans in the Mediterranean coastal desert of Egypt. Its specific objectives were :

1) to foster research for broadening the base of ecological information, which would directly or indirectly contribute to the practical development needs of the area ;

2) to construct simulation models of the ecosystems in the area that would help in crystallizing the collected information, pointing out the gaps in knowledge about these ecosystems, assessing relative priorities for further research, and ultimately providing recommendations for formulating rational land-use schemes ;

3) to provide training for junior ecologists in integrated and interdisciplinary research, and in a variety of advanced ecological techniques including laboratory and field methods and simulation modelling.

During the 1974-1976 period, a major step was made towards filling the gaps of knowledge about the structure and functions of the major ecosystems in

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* *Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt.*

** *Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt.*

this region, and the integration of information on these ecosystems. The general emphasis was directed more to the state-of-the-system measurements, since information about most components of the ecosystems was scanty at the time when the project started ; but studies on some processes were also initiated. Periodic measurements of most of the state and exogenous variables (mostly climatic), thus provided a more or less complete picture of the monthly (or seasonal) fluctuations in the state of the system. These measurements included : biomass and phenology records, and estimations of the chemical constituents, for plant species representing different life forms, population and biomass determinations of vertebrates, invertebrates and micro-organisms, and records of soil moisture content and climatic factors. Starting 1976, process studies were carried out in various fields, beside the state-of-the-system measurements. Of these studies, mention may be made of growth, germination and transpiration of common plant species, feeding of common vertebrates and invertebrates, and decomposition of litter, nitrification and ammonification by micro-organisms.

By the end of 1976, SAMDENE has reached a turning point in its activities. While the state-of-the-system measurements and the process studies mentioned above were continued, others were initiated, as soil respiration, humification and mineralization of soil organic matter, feeding, respiration, defaecation and water relations of soil animals, and nutrient cycling between the soil and common plant species. Efforts have been also directed towards two main themes : evaluation of the impact of various types of land use on the structure and functions of ecosystems, and the socio-economic structure and flow of energy in bedouin societies. The state-of-the-system measurements and process studies were continued to serve three major objectives : (a) enriching our knowledge about the structure and functions of desert ecosystems, and thus broadening the scientific base for future management-oriented research ; (b) providing information on temporal variations in state and exogenous variables as reference for the validation of ecosystem models ; and (c) furnishing quantitative means for the assessment of the values of different model parameters that have been estimated previously on the basis of scanty information, intuition or mere guesses.

Studies on the impact of common types of land use on the structure and functions of ecosystems were started in 1977. The most common types of land use in the Mediterranean desert of Egypt were defined and sites representing such types were selected. The following types were the most common, and were more likely to have the greatest impact on the dynamic balance of the ecosystem : (a) grazing and cutting ; (b) dry-farming represented by fig and olive plantations ; and (c) irrigated farming which started after the introduction of Nile water to the region.

Uncontrolled cutting and grazing have dominated North Africa since the eleventh, and have been generally blamed as one of the major causes of degradation of desert ecosystems in this region, exhibited by the reduction of perennial cover, impoverishment of flora, soil erosion, dust storms, formation of mobile sand dunes, and establishment of desert pavement. To that end, the impact of overgrazing and cutting has been one of the main concerns of SAMDENE project since the outset of its activities. Areas were fenced in 1974 at two sites representing two of the ecosystems subjected to uncontrolled cutting and grazing, in order to protect samples of ecosystems in these areas from such activities. This served three purposes : (a) furnishing locations for validation measurements where the effects of all but the state and exogenous variables of the ecosystem were excluded ; (b) demonstrating the variations that would take place in the ecosystem by protection, for different lengths of time, after a long history of cutting and overgrazing that was culminated by the present state of disclimax stability ; and (c) providing a means of describing the state of the ecosystem at one end of the gradient of grazing intensity, in any experiment dealing with the effect of this factor.

Additional areas were fenced in 1977 at Omayed in which grazing intensity was fixed at certain limits, with the aim of providing a means of describing the state of the ecosystem at different points between the two ends of the gradient of this factor : one end representing no grazing (furnished by the area inside the old exclosure) and the other end representing free grazing (furnished by the area outside the exclosure). Beside the records on different state variables in these areas with different grazing intensities, investigations of the feeding habits of domestic grazing animals and palatability of plant species were started.

For evaluating the impact of some types of farming manipulations on the structure and functions of ecosystems in the project region, five sites representing these types were selected : (a)fig plantation under dry farming on the coastal sand dunes at Omayed ; (b) fig plantation under dry farming in the inland depression at Omayed ; (c) olive plantation under dry farming in the inland depression at Burg El-Arab ; (d) olive plantation which was turned to a crop field under irrigation with Nile water, in the inland depression at Burg El-Arab ; and (e) vine plantation under irrigation with Nile water, in the inland depression to the south of these agro-ecosystems.

The changes where monitored that might have occured in soil physical and chemical properties, populations and activities of soil micro-organisms, and soil fauna, and populations and activities of insects, due to different manipulations taking place in these ecosystems, in comparison to unmanipulated ecosystems.

Modelling activities were started at an early stage of SAMDENE. At first, a preliminary version of a whole-ecosystem model was prepared, incorporating the best existing knowledge of the systems. This served as a valuable guide in collecting field data and in assessing relative priorities for further research. It was so written that the system could be defined at execution time, by specifying the various organisms present, the soil characteristics, etc ., together with initial values of state variables and parameters in the system. Where data for some parts of the system were not available, they were replaced temporarily by informed guesses, or data from similar systems elsewhere. Modelling activities were then continued towards the improvement of the conceptual framework of the whole-ecosystem (DESERT 2) model, and the estimation of more realistic values for parameters, with the aim of getting simulations which would be a closer representation of real-world variations in state and exogenous variables. In the meantime, the accumulation of data on the impact of different types of land use (grazing, dry farming, and irrigated farming) on the ecosystem would allow the orientation of DESERT 2 model to answering questions pertaining to management problems.

The activities of SAMDENE were followed by the initiation of the REMDENE (Regional Environmental Management of Mediterranean Desert Ecosystems of Northern Egypt) Project in February 1979 with the following main objectives:

- Survey and assessment of land resources of representative sectors of the Mediterranean coastal desert of Egypt.
- Evaluation of the impact of different land-use types (grazing, dry and irrigated farming, human settlements ... etc.) on the environment, and on the values of resources.
- Synthesis (using modelling techniques) of the collected information for use by decision makers as a guide for management of resources and optimization of regional development.

The work in REMDENE project consists of the following activities :

1. In order to provide a broad base for land resource assessment and evaluation of potential for reclamation, maps are prepared for representative sectors of the western Mediterranean desert (either from earlier sources or especially prepared) of land-forms, topography, soils, hydrology, vegetation, and ancient and modern land-use patterns. Aerial and satellite photos are used. Maps of landforms, topography, soils and hydrology will assist in the evaluation of water resources, its conservation and rational utilization which is vital to the development of arid regions. Maps of vegetation will help to assess the primary productivity of natural ecosystems, and depict the distributional patterns of species of range values, or with useful natural products (e.g. of medicinal value), or those which can be used as indicators of environmental properties of human activities. Maps of land use patterns, both ancient and modern, will help to enumerate and delimit the extent of different kinds of manipulation which need to be evaluated. Former and contemporary patterns of land-use as practiced by the ancients, and by indigenous population must be well understood to maximize their merits.

2. Mapping of environmental and biological variables mentioned above would form a base of land-resources assessment, which could be a useful tool for environmental policy-making. The procedure for land-resources assessment is envisaged to go through several steps. First, different land units are identified and described on the basis of such criteria such as landforms, topography, hydrology, soils, and vegetation. An evaluation of the natural state of units then follows with the assessment of the extent of human intervention, and the impact of such intervention on the present state of

the natural system. Areas most disturbed are to be identified from those with a more or less natural state. The state of natural resources in each unit is to be rated according to the extent to which the area is urbanized, under grazing, in agriculture, in extractive activity ... etc. Units are also to be rated according to the degree of erosion, shrub cutting, and water use.

The next step is then to evaluate the potential for reclamation. Thus, units may be classified between two extremes : units of the lowest potential (with skeletal and shallow soils, meager water supply, scanty vegetation... etc .) and units of the highest potential (with deep soils, adequate water supply, good vegetation cover ... etc.).

3. The various forms of land use in the past few decades (e.g. grazing, rain-fed fig, olive and barley cultivation, intensive irrigated agriculture, and different types of combining agriculture with livestock breeding) constitute different kinds of manipulation which need to be assessed in order to judge the extent to which they have affected the ecosystem, for better or for worse. Measurements started in SAMDENE on the vegetation, invertebrates, micro-organisms, soil physical and chemical properties...etc. are extended to agro-ecosystems. This will serve the useful purpose of monitoring changes against the background of more or less natural ecosystems.

Mapping is considered to be one of the most efficient tools for synthesizing and integrating ecological information in form that could be readily useable by decision-makers in planning management policies. The idea of preparing maps for decision-markers was adopted prior to the initiation of REMDENE, when a contact was made during the last year of SAMDENE (1978) with the staff of the phyto-ecology section of the French CEPE/CNRS in Montpellier. Since that time, mapping activities have been developed to include : (a) mapping of land cover ; (b) mapping of soils, and (c) mapping of human settlements, with the objective of producing integrated maps. Mapping of land cover has progressed to include most of the area between Burg El-Arab and El-Alamein. Mapping of soils included two activities : (1) the preparation of a generalized map of soil types and land potentialities for the whole western Mediterranean coastal region utilizing available information in previous surveys and studies, and (2) the production of a semi-detailed soil map of the Omayed sector for integration with the land cover map. Mapping of human settlements was also started. This report represents an integration of these mapping activities. It is hoped that it will provide some help for making sound management decisions in that sector, and in the meantime represents a model for extending such type of mapping activities to other sectors of the western Mediterranean coastal region of Egypt.

b) *Thematic Mapping of Ecologically Oriented Surveys of Land Resources for Sound Land Development*

by Gilbert, A. LONG

The main objective of editors and authors of this publication is double : on one hand, they intend to demonstrate that thematic mapping is an efficient tool for spatial expression of data and results related to the inventories and the evaluation of renewable resources in a given area ; on the other hand, using thematic mapping as a means for transferring knowledge, communication and dialogue, they are willing to provide answers to social demands as expressed at the level of decision makers who are in charge of programming the regional economical development and who agree to include, step by step, in their development plans some appropriate measures to ensure the preservation of the environment and the conservation of resources, in a long term strategy.

The publication of a set of thematic maps of the same area, could give the illusion that editors and authors of this paper are making a task which could be classified as a project of "regional geographical atlas". This is not the case : conception and representation of so numerous mapping themes, and the rational choice of mapping units, mapping scales and also of the graphic representation systems, are together a deliberate choice for the implementation of an original work, voluntarily organised according to the guidelines indicated in the title of this publication.

It is, in the meantime, a document on methods of ecological diagnosis and of mapping of results of this diagnosis ; but above all, it is a training and informating document devoted to critical analysis, in particular for suggesting the conditions that we should meet to reach a level of generalisation of mapping themes for the whole, or parts of the geographical area referred to as the "western Mediterranean coastal region of Egypt".

Considering the methodological aspects - which include, in this case, the training on-the-spot of Egyptian research assistants while the adaptation of methods used elsewhere was attempted, it is desirable to recall what I wrote in 1979 during the SAMDENE Workshop concerning mapping : "Mapping of renewable resources of the coastal western desert of Egypt is a long term task which implies methodological adaptations and training of relevant specialists".

At present, this objective appears to be not yet fully accomplished. In fact, on one hand, technical facilities and staff have never been available to meet the ambition suggested in the list of proposals produced during the SAMDENE Workshop, when REMDENE project started ; and on the other hand, we had to test the proposed methodology with only one test-area (El Omayed) and, consequently, we are running the risk of weak representation of the whole region under consideration.

Finally, scientific integrity must urge us to recognize the difficulties of expressing the whole spatial distribution of some themes which would yet require considerable research and field work, in order to have results at a scale entirely compatible with the variations of factors considered as most discriminant.

We do emphasize here that every mode of mapping representation imposes a compromise, a sort of optimisation process between various points of view that are sometimes contradictory, depending on the objectives and the problem dealt with. Thus, for ecologists who are studying spatio-temporal variations of some properties of a few plant and/or animal populations, mapping themes presented in this document cannot be more than a geographical frame for localising these properties and associated phenomena, or a depiction of environmental conditions from which they may consider one or the other, in order to carry on their own observations, measurements or experiments, while they are mainly often applicable only to one site considered as "representative". But, if the ecological research is developed on the ground of biocenosis and ecosystems units, or even at the level of ecological landscape units and of the interactions between ecological systems (s.l.), the thematic mapping constitutes, according to our knowledge, a standard way, and often a necessary channel to formulate and to express the results.

Why necessary ? mainly because the ecologist - as well as the geomorphologist, and the soil scientist, ... - aim at expressing, as far as possible, the comprehensive nature of the spatial distribution of the involved themes. In a few words, he must consider the whole area, without any "blank unknown areas on the maps", and his duty, for a given theme, is to take into account - and to explain - all specific cases which are present in the considered area. This rule implies another one of equal importance : the necessity to understand the spatial organisation of the described units and their reciprocal relationships according to the patterns of variability of criteria and parameters which characterise them ; to conclude, the question is : to what extent we must take into account the real heterogeneity, at a given level of perception of the ecological landscape units, and of the described units in terms of taxonomic composition (i.e. list of plant species which constitute the plant communities), of structure, function and evolution of ecological systems?

To describe landscape (or land) units which belong to such a conception of ecological approach is of course a difficult task, considering the fact - as it is the case - that we have to deal with complex and changing systems. But the undertaking is not impossible if we proceed rationally and keep in mind the general rules which govern the functioning and evolution of the biosphere ; indeed, it is not only the very specific rules of the evolution of particular plant or animal species which will help us to meet the full explanation of the complexity of the present ecological systems. Of course, the two approaches should be considered as complementary ; therefore, considering the REMDENE objectives, only the first approach (comprehensive, holistic) is capable of producing results which are directly operational for environmental assessments and control, as well as for land development in rural areas.

We should mention that this ecological description of land units and the associated resources, also comprises some very analytical aspects, easy to survey and to map. This could be considered as a marginal scientific task, if we exclude the fact that the choice of such criteria requires, firstly comprehensive ecological thinking, and secondly a sound decision.

On the other hand, synthetic and/or relational aspects (relations between variables, or between systems) are subject to more easy criticism, particularly when they are represented by research data that are not yet elaborated, or unsufficiently related to the proposed rational (as it has been expressed in the REMDENE project), or insufficiently worked out in depth where it is necessary to do it. Therefore, in having the will to try to explain much and much more, and in breaking down mechanisms of the systems, we aim at a very schematic reductionist fashion, and we thus lose the advantage to express - of course also with some risk - the comprehensive fashion of the phenomena and the real complexity of the variables and the systems dealt with.

What would be the benefit to say, for instance, that the primary productivity of a given phytocenosis is of x grams of plant dry matter measured in 1 m^2 during march 1978, if the spatial and temporal variability of this variable is such that it exhibits considerable variations. It may be more wise in this case to express, at least, only the calculated mean values on several periods and on several site conditions, preferably with their confidence intervals. To be pragmatic, and to consider the test-area of El Omayed, it is necessary, when expressing the mapping of the plant production theme, to indicate the relative values of this production by categories of uses and classes. This accuracy is sufficient ; it is more realistic and, moreover allows, when transferring the results to application areas, to take an attitude of reservation which will be appreciated by planners of rural development.

Because rural development for and by agriculture is the main topic of this publication, we must now recognize that this development will depend on our relevant data about plant production, or let us say, the capability of man to develop the best potentialities for plant production. The published document aims at indicating, for various types of plant resources, either spontaneous (i.e. grazing resources) or cultivated (i.e. rainfed barley ; irrigated crops), what are the environmental constraints which must be considered as the most difficult to change (except at high costs), or those which could be easily changed in order to increase the production(s) of these resources, and to maintain that increase as long as possible (several decades according to the ecological overview of development) at a level which is socially and economically interesting, and with no severe deterioration of the environment. Besides, the localised perturbations linked to implementation of some technologies of production, could be corrected by the application of appropriate technologies at the lowest costs. The risk, which we should avoid, is the one of overpassing the irreversibility thresholds. In the north western coastal desert of Egypt, examples are not lacking of ecosystems which are radically modified after the implementation of so called "modern technologies", which lead to notable symptoms of long term deterioration of the environment, such as the areas which are irreversibly deteriorated due to land salinization as a consequence of faulty irrigation techniques, or those which are subject to accelerated desertisation processes as a consequence of the eradication of plant species, particularly on sandy soils where aeolian erosion takes place.

It was so important that all partners contributing to this publication, could have expressed their opinions concerning the sensitivity of resources of rural area as related to their present state. Temptation would be great for conservationist ecologists to propose complete protection of the involved marginal lands and putting them for a long time in a "exclosure" system. Such a strategy is hardly acceptable for Mediterranean coastal region of Egypt. An alternative to this strictly intellectual and "conservationist" idea, is proposing an optimal localisation, as much as possible, of the potential use of renewable resources of the rural area, which could cope as best as possible with the capability of biological perpetuation of the systems in consideration.

Therefore, taking into account the present deterioration conditions, ecologists would be more justified in a debate about a policy for preservation and safeguard of the environment, in proposing further integration in a comprehensive land development programme, without neglecting any small areas of the total territory to be managed.

With this point of view, we emphasize the strategy proposed by UNESCO (M.A.B. Programme) concerning the Biosphere Reserve, which is very relevant, and call the attention of ecologists, planners and decision makers. We are very glad that Egypt has already proposed El Omayed test-zone as a biosphere reserve. It remains that the ecological bases for rural development as briefly presented in this publication, of course not yet sufficiently, will be really taken into account by land developers, land managers and rural producers.

In order to achieve this aim, we are in favour of adopting a multipurpose, integrated, self-reliant development scenario, giving the preference to the socio-economical requirements of the main actors of production - farmers and animal husbandry producers - a scenario which is capable of bringing up a "surplus" of total production which, when put in the market, would develop the necessary exchanges without which there is neither development, nor preservation of the environment, nor social progress.

At the end of this introductory section of this publication, it is our duty to express pessimism concerning the chances of implementing such a scenario which implies, in a voluntary and sustained way, more intellectual investments and in-depth undertaking of specific studies, as well as the implementation of pilot-projects at the right scale.

Scientific and technical cooperation which has been engaged during last years with REMDENE project teams and the French institutions has shown the way to be followed. With unsufficient facilities, this publications has proved today, that the challenge could be won if there is a will to persevere the effort. Let us hope that this message will be understood by the people in charge of the institutions, who have the power and the capability to finance research programmes related to land development and studies which are still necessary in order to extrapolate from only one test-area (such as El Omayed) to the whole western coastal desert of northern Egypt.

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PART I

CONCEPTUAL AND METHODOLOGICAL APPROACH

The main objective of this document, as viewed by the scientists who participate in it, is to provide an expression of proper integrated field research which may help in formulating answers for the diverse problems relevant to the regional development of the northwestern coastal belt of Egypt. The treatment of these diverse problems call for the evaluation and understanding of the relationships between ecological and sociological systems, and for the rational utilization of resources and the maximization of production.

The integrated studies in the whole region of REMDENE seemed impossible and it become obvious that we had to concentrate our effort to a limited sector with the hope of extrapolating the results to a more vast area with the same general features.

While it seems possible to apply the methodology followed in the report to other areas in the region, it is obvious that the main ecological features are not homogeneous and that the results of one site cannot be applied to the whole region. For good representation, therefore, it is necessary to collect information from several test sites. As has already been suggested, three such test sites is the minimum number for adequate representation of the whole region.

This report deals with research results obtained for the sector of El-Omayed (Fig. 3) which represents the area extending from near Burg El Arab till midway between Dabaa and El Alamein. This area is characterized by the presence of three of four prominent ridges running parallel to the coast. These ridges are in fact ancient consolidated dunes which provide a surviving evidence of the successive positioning of the coast. The part of this area east of longitude 29°36' is strongly affected by urbanization, and is therefore not represented by the El Omayed area. El Omayed study area is priviliged by the presence of an ecological research site where numerous integrated ecological studies have been conducted since 1974. It is now a UNESCO biosphere reserve. Complementary studies were carried out between 1974 and 1979 in a research site on the coastal sand dune of Gharbaniat 54 kms west of Alexandria. It is conceivable that the results of these studies would be more profitable for scientists, decision-makers and users, if they were used in developing land cover map. This requires that every research worker uses techniques that make possible the localization of measurements and the delineation of zones at different spatial scales that they wish to describe and to evaluate. Aerial photographs are still the traditional tool for such an approach, taking into account the desired level of accuracy for the expression of results. Aerial photography in panchromatic pictures has often been used as well for study of the present state of land and resources and for the definition of potential states. Aerial photographs taken in 1954, 1962 and 1979 have been used in our studies, taking into consideration necessary adjustments due to small modifications of scale. Data of remote sensing (imageries and numeric data) have not been used except for the soil study. They are however useful for the quick delineation of various subareas, so that each may be then studied in more detail, and of physiographic units as they are described in this work.

Studies of resources conducted in an evolutionary context necessitate to take into account the dates of these studies. Certain practices, for instance those which involve ploughing, have changed quickly at El Omayed. As a result, our field observation (for instance the extension of cropping in 1981) obliged us to modify considerably the delineation of certain units that were obtained by interpretation of the aerial photographs of 1979. The rapid evolution during the last few decades leads us to use the aerial photographs of 1954, 1962 and 1979 for studying the dynamics of the considered areas and the evolution of specific characters. Alternatively, we used data of field mapping (1981 or 1982 according to the theme) for studies of resources evaluation.

The general objectives of the present publication are :

- to establish an inventory of present resources (vegetation, animals, water, soil ...) and to propose a qualification of their status and possibly of their sensitivity ;

- to establish the inventory of social systems, which are concerned with the exploitation of these resources in a long term and to define the long term strategies for development on ecological bases.

These general aims are diagnostic and in general are more ecological than sociological.

The main facts and the results of such diagnosis are expressed mainly by multithematic mapping representation which provides a means of generalization and evaluation of the present states. The application of this technique to the study area of El Omayed, contributes to the methodological progress and provides a framework for the presentation of the data on scientific and technological bases.

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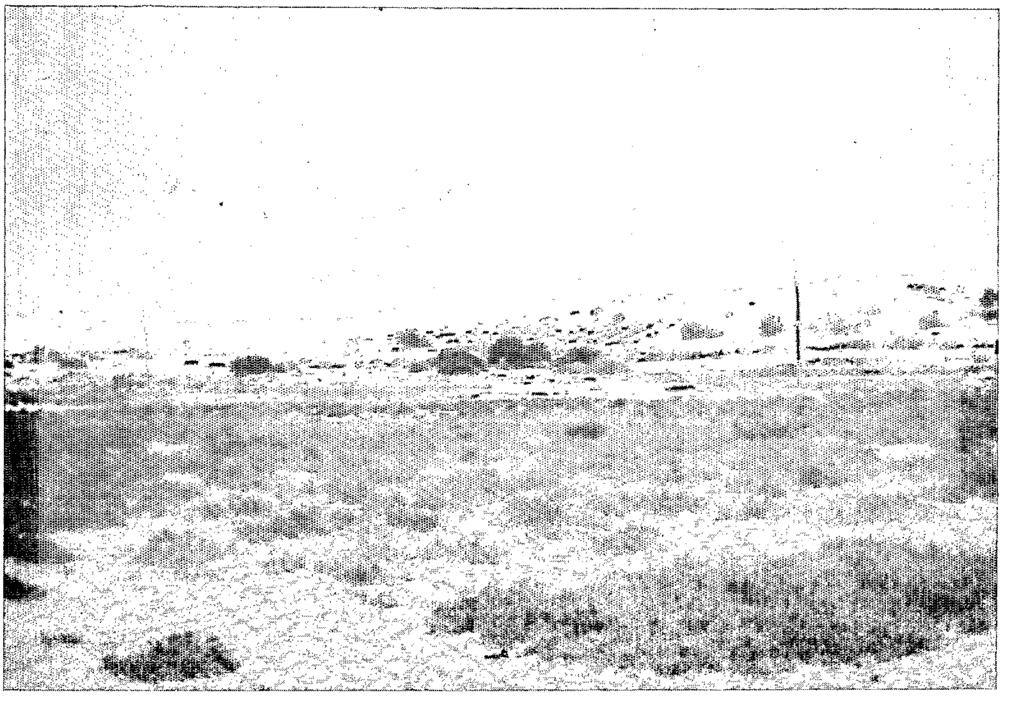


Rangeland of low ligneous plants in the saline depression. *Limoniastrum monopetalum* the dominant species is an indicator of salsodic soil and of a water-table more than one meter deep.

El-Omayed - June 1982.

Deterioration of environment (impoverishment of the natural plant cover, ablation of soil by deflation and aeolian dune formation) in cultivated area.

El-Omayed - November 1981.

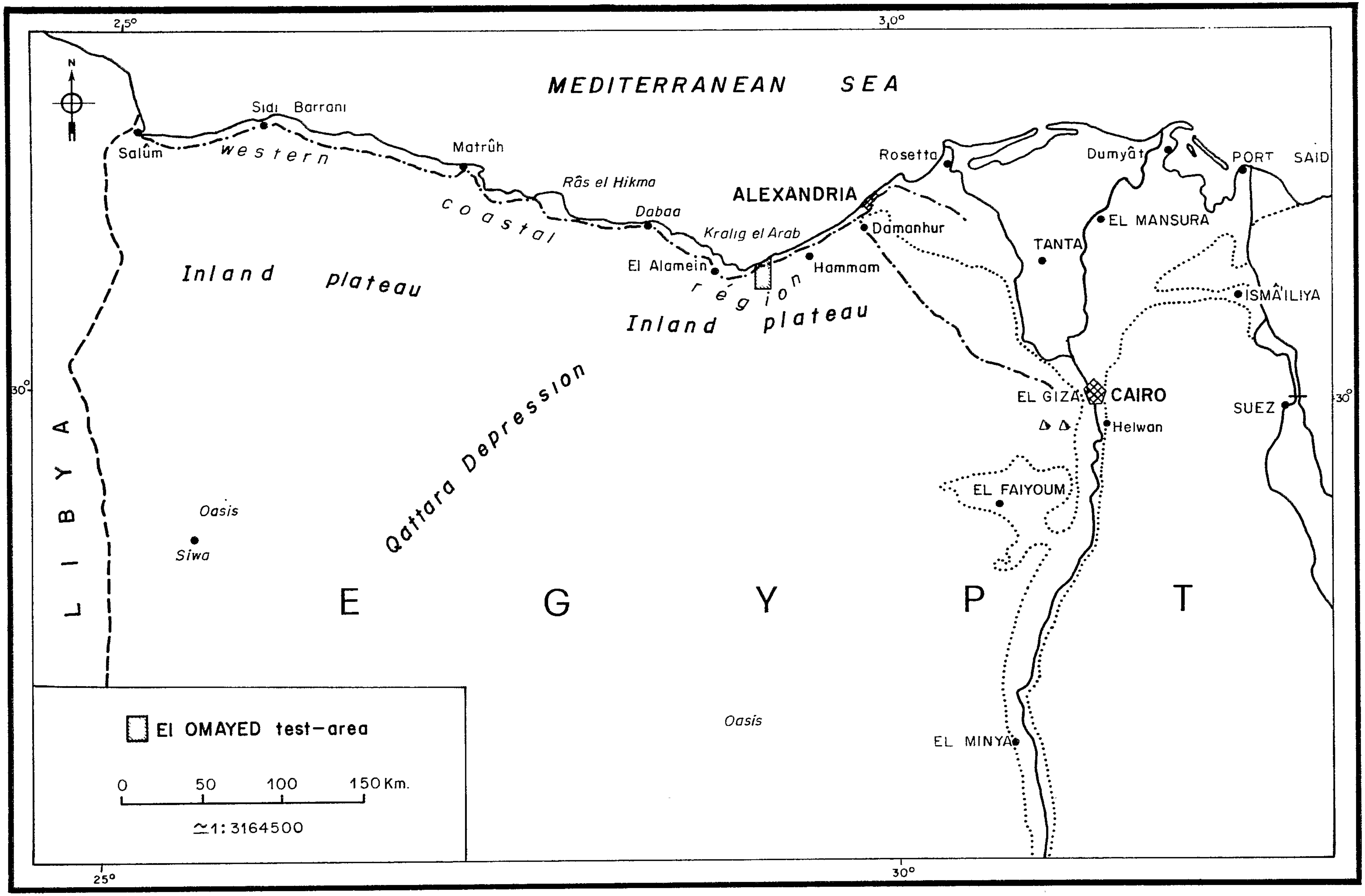


Figure 1 - LOCATION OF EL OMAYED TEST AREA IN THE NORTHERN COASTAL REGION OF EGYPT

PART II

CASE-STUDY OF EL OMAYED TEST-AREA

As we have already mentioned El Omayed test-area is the zone in which the ecological studies carried out by REMDENE investigators may be used to provide better understanding of the management problems of the "western-Mediterranean coastal region" of EGYPT. It is conceivable that the ecological features of this region are not homogeneous. Therefore, in order to recognize which features can be extrapolated, from the test-area to other areas in the region, we will try in the following paragraphs to outline at first the general features of the whole region, especially those related to the main ecological factors and then to mention those which are more specific to the test-area.

1.- Location

El Omayed test-area is about 5,000 ha ; it may be considered representative of a more extented territory, approximatively 100,000 ha in the "western coastal desert" of EGYPT (which extends to about 1,000 000 ha) (Figure 1).

The extended territory lies between the meridians 28°42' and 29°23' (Figure 2). The test-area itself is located between the following coordinates : latitude North 30°44'30" - 30°49'40", and longitude East 29°09'45" - 29°12' 53".

Concerning the administrative situation, El Omayed test-area belongs to the Governorate of the Western Desert, and the "Township" of El Hammam.

2.- Physiographic systems

Many physiographic units may be distinguished in El Omayed test-area due to the variability of edaphic, topographic and geomorphologic features. Beside these features, biotic factors, including the impact of man help in characterizing landscape units.

In the extended territory represented by the test-area, the topography becomes higher in an irregular fashion from the coast inland (Figure 3). The relief is characterized by successive undulations running more or less parallel to the coast. These undulations are in the form of calcareous rocky ridges (ancient dunes) alternating with depressions. Several ridges start near Lake Mariut and become gradually less obvious towards the West. At El Alamein,

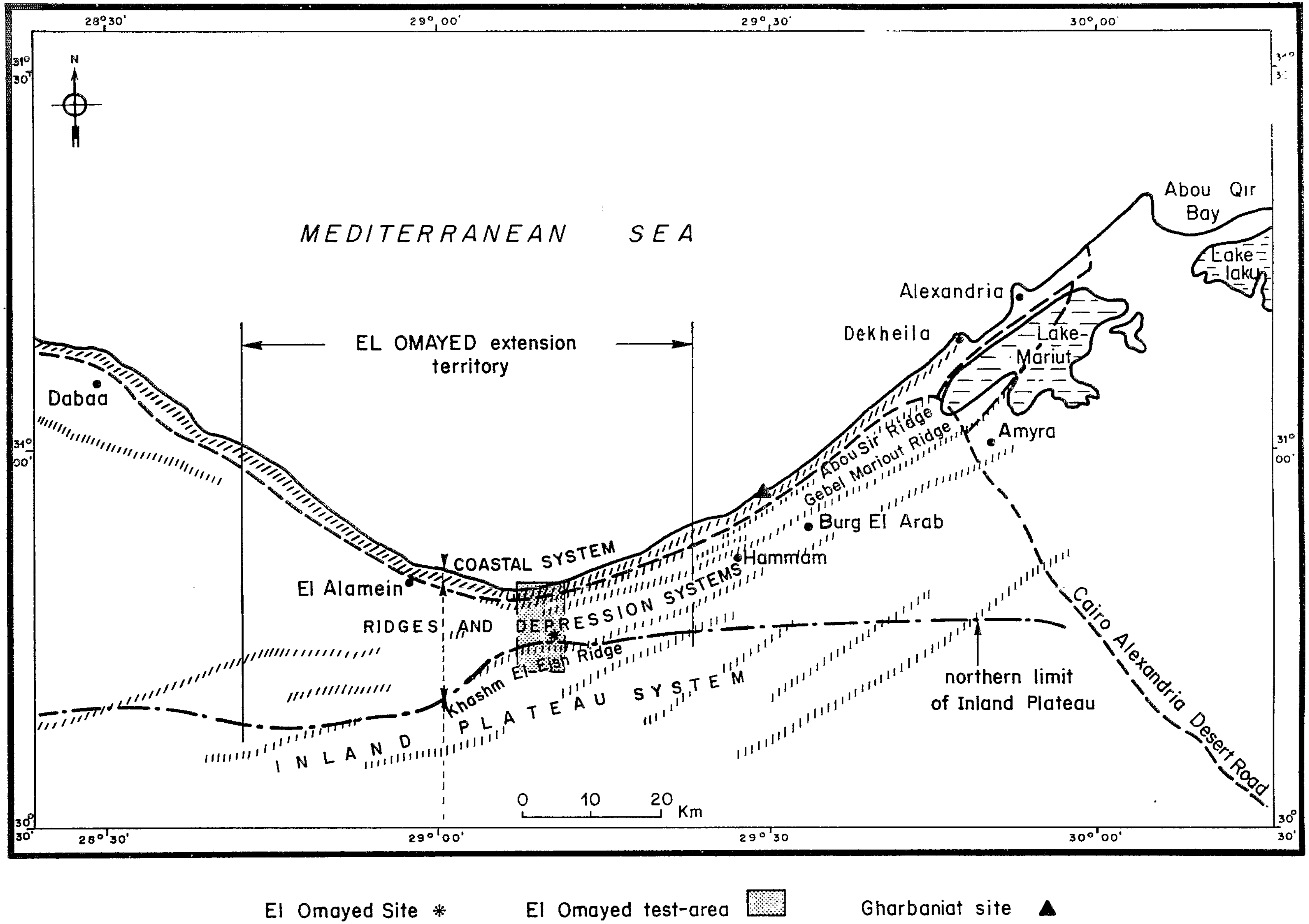
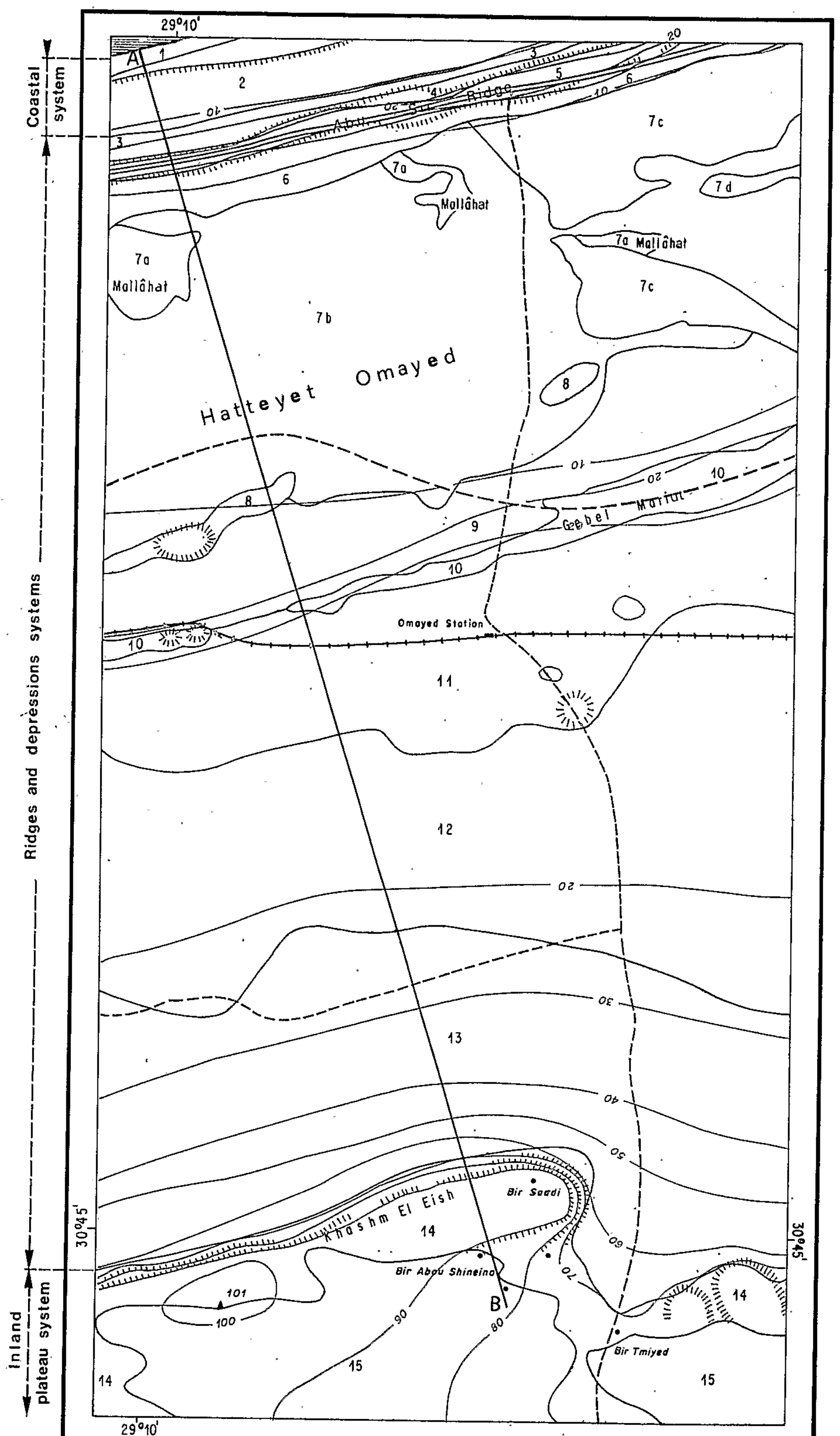


Figure 2 - LOCATION MAP OF EL OMAYED TEST AREA AND EXTENSION TERRITORY

PHYSIOGRAPHIC MAP

EL OMAYED TEST-AREA



Drawn Jan. 1963 C.E.P.E. L. Emberger.

Scale 1: 50 000

Contour Interval : 10 m

Figure 3

LEGEND

	N° of unit on the map	designation of the unit	distance from the sea	altitude (m)	surface (ha)	main geological and geomorphological features	present human action
Coastal system	1	beach	0-200 m	0	17		0
	2	coastal sand dunes	200-500 m	0-10	126	present active dune on consolidated material	L-M
Ridges and depressions systems	3	first depression	500-900 m	2-5	27	flat and stretched depression (sand deposits)	H(p c)
	4	northern slope of the first rocky ridge	600-900 m	5-15	34	hillside (sandy colluvions)	H(p g)
	5	first rocky ridge	900-1100 m	20	62	summit of stretched hill (oolithic limestone, ancient consolidated dune)	VH(bg)
	6	southern slope of the first rocky ridge	1-1.3 km	5-10	102	hillside (sandy colluvions)	VH(bpcg)
	7	saline depression					
	a	. salt-marsh	1.1-2.5 km	3	60	waterlogged depression (loamy and clayey sand)	0
	b	. hummocky depression	1.1-3.5 km	5	844	flat area, locally waterlogged, with numerous sandy hummocks)	M-H(gc)
	c	. sandy meso-deposit	1.1-3 km	12	219	gentle and irregular slopy sandy hill	VH(p)
	d	. sandy indurated convexity	2 km	7	9	low and stretched convexities (indurated sand)	VH(b)
	8	second rocky ridge	3 -3.3 km	17	27	summit of stretched hill (oolithic limestone, ancient consolidated dune)	VH(b)
	9	interidges sandy slope	3.3-4 km	15-20	316	gentle slopy surface overlain by drifted sand	VH(p c)
	10	third rocky ridge	4.3-4.6 km	20	98	summit of stretched hill (oolithic limestone, ancient consolidated dune)	VH(b)
	11	southern sandy slope of the third rocky ridge	4.6-6 km	15-20	504	gentle slopy surface overlain by drifted sand with some small convexe strongly indurated surface	VH(bpcg)
	12	non saline flat depression	5.5-7 km	15	927	plain more or less drifted	H (g)
	13	sandy glacis with gullies	6.5-8.5 km	15-40	934	sandy glacis dissected with gullies in the upper part	VH(pcg)
Inland plateau system	14	cliff and outcrop of inland plateau system	7.5-8.5 km	40-80	276	cliff with outcrop of calcareous sandstone and stretched and gentle slopy inland plateau	H (g)
	15	undulating sandy surface	8- 10 km	75-80	408	slighty undulated surface with drifted sand	H (gc)

- Level of human pressure : 0 = negligeable ; L = low ; M = medium ; H = high ; VH = very high
- human activities : b = human settlement ; g = grazing ; c = cropping ; p = planting

Note : AB = topographic transect see description Figure 4

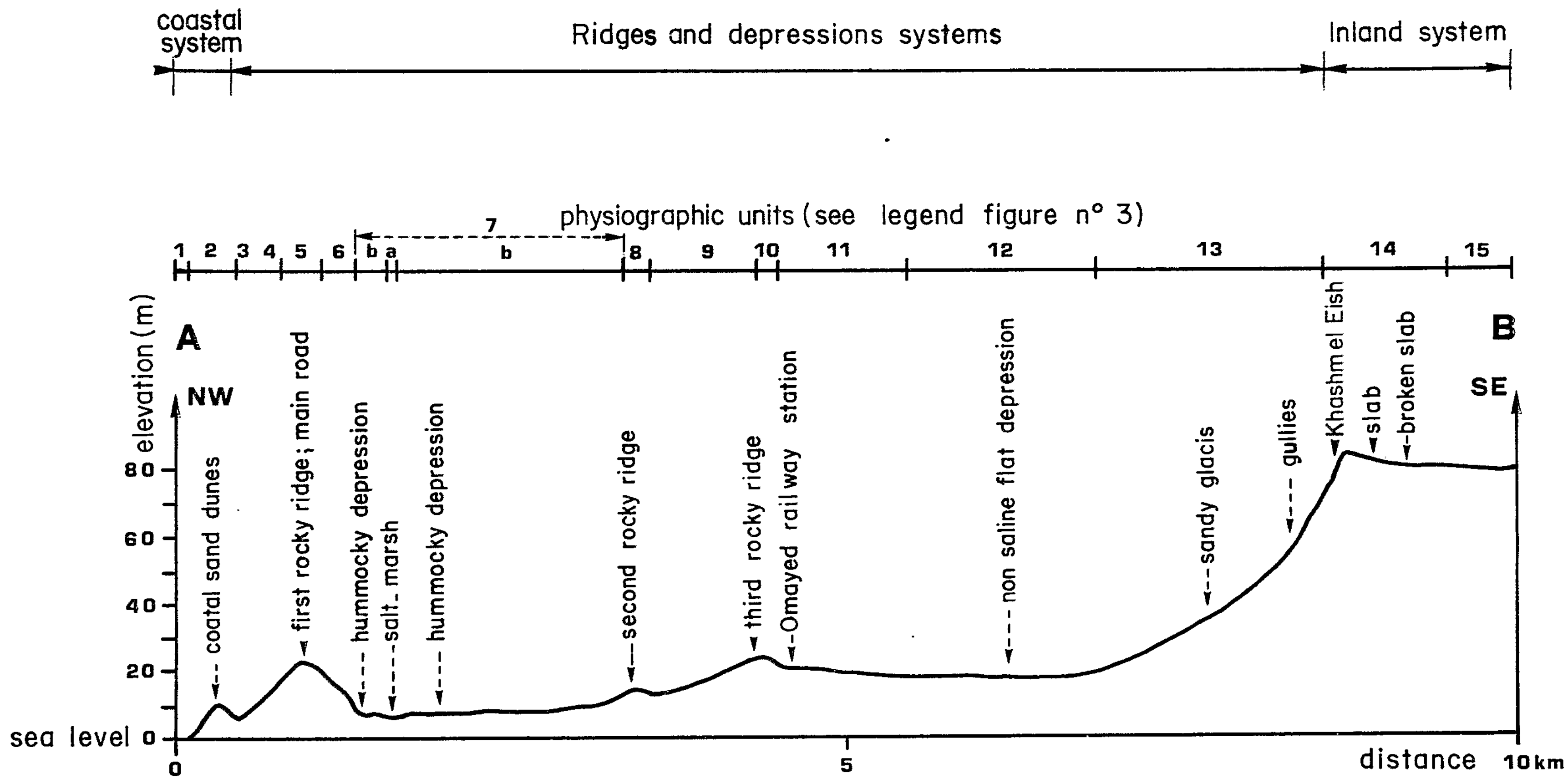


Figure 4 - LOCATION OF PHYSIOGRAPHIC UNITS ALONG A TOPOGRAPHIC TRANSECT FROM THE SEA TO KHASHM EL EISH (EL OMAYED TEST-AREA)

ridges progressively diverge from the shore. Only coastal sand dunes are well represented along the whole region.

The main features of the various physiographic units lead to the distinction of three major physiographic systems :

a) *a coastal system* which covers a small part of the territory, including the beach and the coastal sand dunes ;

b) *ridges and depressions systems* which constitute the main part of the territory including the ridges, their gentle slopes and the more or less large depressions ;

c) *the inland plateau system*, close to the inland desert.

Figure 4 shows the relative locations of these three major systems, and the distribution of the physiographic units as can be described on a topographic transect from the sea shore in the North to Khashm El Eish ridge in the South.

3.- MAIN ECOLOGICAL FEATURES

3.1. PRESENT STATE.

3.1.1. Climatological variables and systems.

Three main factors control the climate of this region :

. the situation with regard to the general circulation of atmosphere ;
. the proximity of the Mediterranean sea ;
. the orientation of the coast.

The first factor is undoubtedly the most important one. The proximity of the sea has a direct effect on temperature and humidity, and consequently on evaporation and condensation, but does not affect the amount of rainfall. The orientation of the coast with regard to the prevailing wind probably provides explanation for differences in the distribution of rainfall along the coast.

The general features of the climate of El Omayed extension territory may be indicated by the averages of 30 years records from 1946-1975 at Burg-El Arab (30 km to the East of the study-area) and Dabaa (90 km to the West of the study area) meteorological stations (Table 1). These are the two closest stations to the test-area from which records of 30 years could be sustained.

Table 1. Climatological normals for Burg El Arab and Dabaa meteorological stations near El Omayed (based on records from 1946 till 1975).

Station	Altitude (m)	Distance from the sea (km)	P (mm)	M (°C)	m (°C)	RH %
Burg El Arab	10	5	168.9	24.1	14.3	66
Dabaa	18	6	140.4	24.3	14.2	68

where P : annual mean rainfall.
M : annual mean maximum air temperature.
m : annual mean minimum air temperature.
RH : annual mean relative humidity.

The rainy season begins during the second half of October. About three quarters of the total amount of rain falls from November to February. December and January are the rainiest months with an average of 35 mm per month. Some showers are still observed in March, but the spring is dry and receives only about 10 % of the total. The average number of days with rainfall of more than 5.0 mm, during the year, varies between 5.2 in Sallum and 11.7 in Alexandria (Table 2). It is generally considered that regular dryland farming is practically impossible with a rainfall which is so scarce and so erratic.

Table 2. Mean number of days with rainfall of 5.0 mm or more.

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Alexandria	2.6	2.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.7	1.9	8.9	11.7
Dabaa	1.7	0.7	1.0	0.1	0.1	0.0	0.0	0.0	0.1	1.2	1.2	1.9	8.0
Mersa Matruh	1.7	0.9	0.6	0.1	0.0	0.0	0.0	0.0	0.1	0.7	1.3	1.9	7.3
Sidi Barrani	3.2	0.5	0.7	0.1	0.0	0.0	0.0	0.0	0.0	1.2	0.8	2.2	8.7
Sallum	0.0	1.0	0.5	0.0	0.2	0.0	0.0	0.0	0.0	1.3	0.0	1.2	5.2

Expectancies of the number of occasions per 100 years that certain ranges of rainfall will occur in Burg El Arab as calculated by AYYAD (1983) are indicated below (Table 3).

Table 3. Expectancies per 100 years of certain range of rainfall (Burg El Arab)

Range of rainfall/year (mm)	Expectancies per 100 years
< 50	9.0
50 - 100	16.5
100 - 150	24.9
150 - 200	25.1
200 - 250	15.8
> 250	8.7

Dew in arid and semi-arid regions is a valuable source of moisture to plants. Climatic conditions in the Mediterranean region of Egypt are in some seasons favourable for water vapor condensation, such as considerable temperature gradient between different soil strata and overlying air, high relative humidity and still wind particularly during summer and autumn. The gain in moisture content due to water vapour condensation on the sand dunes was estimated by MIGAHID & AYYAD (1959) as ranging between 2.35 % and 4.71 % at Ras El Hikma, and a total amount of dewfall of 11.5 mm was recorded during 1955. At Burg El Arab, ABDEL RAHMAN *et al.* (1966), recorded gains in soil moisture content due to water vapour condensation varying from 0.4 % to 1.4 %.

Winds in the study area are generally light, but blows strongly during winter and early spring. Climatological normals (FAO 1970) indicate that the average wind velocity at Mersa Matruh and Sidi Barrani is about 20 to 25 km/hr. The end of summer records many calm days, and the average speed dropt to 15 km/hr. The wind speed at Alexandria and El-Dabaa is 25 % lower. North-west winds prevail with frequency of 30-40 %. South-west winds have some importance in Mersa Matruh and Sidi Barrani with frequency of 18.6 % - 13.5 % respectively. Table 4 indicates the surface wind speed at Mersa Matruh and Dekheila (Meteorological Authority, 1975).

Table 4. Mean surface wind speed (knots) at Mersa Matruh (period 1952-1975) and Dekheila (period 1957-1975).

Stations	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Mersa Matruh	11.8	11.8	12.2	11.1	9.5	10	10.1	9.2	8.6	8.3	9.3	11.4	10.3
Dekheila	8.7	8.9	9.6	9.3	8.3	8.7	9.0	8.8	8.1	7.2	7.3	8.0	8.5

The amount of solar energy received per unit area is now generally recognized at the background for quantitative analysis of most of the micro-climatic phenomena of the lower atmosphere. There is no difference in sunshine duration from place to place along the coast, nor from year to year (see Table 5). Cloudiness is greater near the coast than inland. Strong radiation prevails from March till the end of September, with a peak in June-July. November, December and January are relatively cloudy (FAO 1970).

Table 5. Duration of bright sunshine (% of possible) (FAO 1970)

Stations	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Alexandria (1924-45)	68	71	75	82	80	84	86	90	90	87	78	66	80
M. Matruh (1964-65)	65	71	76	71	79	87	91	90	89	78	70	71	79
Sallum (1932-40)	68	68	75	76	72	87	91	92	88	85	69	67	78

The relatively high temperatures prevailing in the study area (Table 1) must have a significant influence on its water balance. A water balance sheet is worked out by AYYAD (1973) for Burg El Arab in order to provide an assessment of moisture surplus and deficiency at different seasons (Fig. 5).

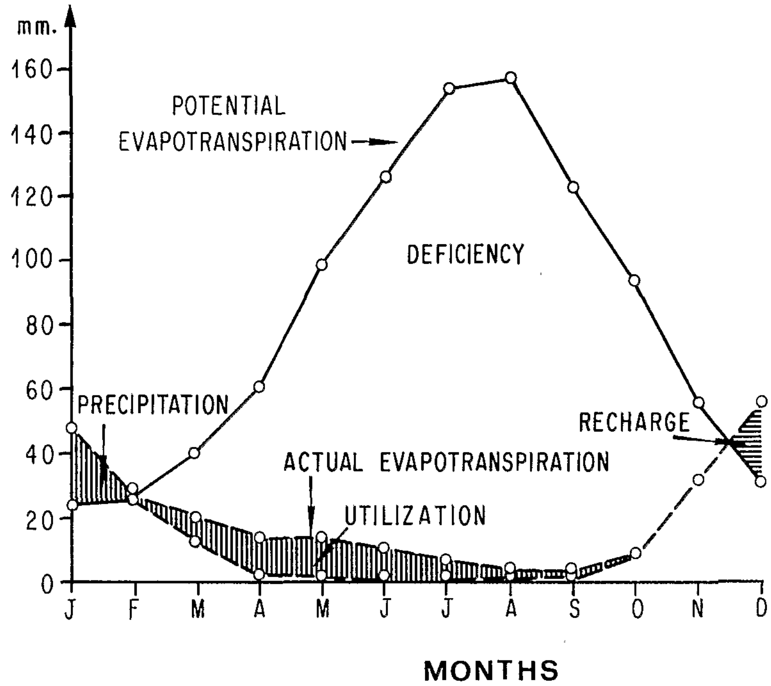


Figure 5 - SEASONAL VARIATION IN PRECIPITATION AND EVAPOTRANSPIRATION AT BURG EL ARAB (AYYAD 1973)

The sequence of water balance is accordingly divided into :

1) a period from December to February when precipitation exceeds water need as expressed by evapotranspiration, but with no moisture surplus, since the excess is used up to recharge the dry soil ;

2) a drying season which extends from February to November when the water need greatly exceeds precipitation, and the actual evapotranspiration falls much below the potential, resulting in severe moisture deficiency.

The monthly variation in potential evapotranspiration (mm/day) calculated by THORNTHWAITE's method for Dekheila and Dabaa stations is given in Table 6.

Table 6. Potential evapotranspiration (mm/day) estimated by THORNTHWAITE's method for two stations along the western Mediterranean coastal region of Egypt (Dabaa and Dekheila).

Stations	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Dabaa	0.95	1.17	1.33	1.91	2.41	3.37	3.80	3.93	3.68	2.87	1.28	2.40	2.40
Dekheila (near Burg El Arab)	0.99	1.24	1.46	1.95	2.59	3.66	3.94	4.33	4.11	2.99	2.25	1.34	2.59

The minimum potential evapotranspiration in winter varies from 0.95 mm/day in January to 2.25 mm/day in December. The maximum in summer varies from 5.37 mm/day in June to 4.33 mm/day in August. The mean annual varies from 2.40 mm/day at Dabaa to 2.59 mm/day at Dekheila.

The Mediterranean coastal region of Egypt lies in MEIG's "warm coastal deserts" (MEIG 1973) : summers warmest month with mean temperature above 20°C ; though occasional short rainstorms occur in winter, but most of the days are sunny and mild. It belongs to the dry climatic zone (Bwh) of KOPPEN's 1931 classification system (as quoted by THREWARTHA 1954), the meso-thermal province of THORNTHWAITE (1948), and the Mediterranean arid bioclimatic zone of EMBERGER (1951).

The meteorological records of El Omayed test-area during 6 years (1976-1981) is illustrated in Table 7. The yearly mean maximum air temperature varies from 24.9 °C in 1978 to 22.9°C in 1979, and the yearly mean minimum air temperature varies from 18.4°C in 1977 to 14.3°C in 1980. Ranges of variation in air temperature between different years are quite small. Most of the rain occurs during winter (November to February), and the summer is dry. The maximum amount received is during either January or December. Annual rainfall varies between different years with a maximum of 106.7 mm in 1977 and a minimum of 15.2 mm in 1981. The relative humidity is much higher in summer than in winter. It varies between 62 % in 1976 and 80 % in 1981. However the variation in this climatic element between different years is small.

Comparing El Omayed climatic records with long-term averages of Burg El Arab and El Dabaa (Table 1), we may note that climatic conditions at El Omayed area, more or less, intermediate between the two stations.

Climatic particulars Gharbaniat were recorded between 1976 and 1979 (SAMDENE) in a meteorological station on the coastal dune at a distance of about 250 m from the sea shore with an altitude of 10 m. Comparing these records with those of El Omayed it becomes obvious that the maximum air temperature (°C) is lower and the relative humidity is higher at Gharbaniat, but there is only a small difference in soil surface temperature. No difference is noted in rainfall records between the two stations. Such difference may only be detected if long-term records are available.

In conclusion, as elsewhere in the northwestern coastal region of Egypt,El Omayed test-area has an arid Mediterranean climate. Rainfall is low, strictly seasonal and uneven in distribution. The harsh conditions resulting from lack of rainfall and high radiation are tempered, however, by the maritime influence of air temperature and moisture.

Table 7. Monthly average of meteorological records of El Omayed from 1976-1981 (altitude 20 m, distance from the sea 9 km).

Month / meteorological element	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1976													
Maximum air temp. (°C)	16.6	16.2	20.8	26.1	26.8	28.5	28.9	28.9	27.1	29.6	25.1	19.2	24.5
Minimum air temp. (°C)	7.9	7.9	9.5	13.8	16.5	20	20	20.1	19	17.6	13.8	9.4	14.6
Rainfall (mm)	0.5	5.1	10.3	-	0.5	-	-	-	-	-	-	-	16.4
Relative humidity (%)	76.5	62.2	63	49.3	48.2	70,9	64.8	70.4	73.4	56.1	48.1	61.6	62
1977													
Maximum air temp. (°C)	15.5	20.2	17	22.6	25.9	29	27.9	29.8	28.3	26	25	18.6	23.8
Minimum air temp. (°C)	9.9	11.5	11,7	23.8	16.6	17.8	22.7	24.8	21.9	20.3	15.3	15	18.4
Rainfall (mm)	29.1	11.4	34	-	-	-	-	-	-	-	-	32.2	106.7
Relative humidity (%)	83	71	81.1	57	64	66	80	76	73	62	58	56	69
1978													
Maximum air temp. (°C)	17.7	19.6	21,7	26.5	28.7	29.5	28.5	27.8	31.4	27.7	19.9	20.1	24.9
Minimum air temp. (°C)	8.3	9.8	10,7	13.5	16.4	19	19.9	21.5	19.7	17.4	14.3	11.8	15.2
Rainfall (mm)	22.7	-	-	-	-	-	-	-	-	-	54.4	21.5	98.6
Relative humidity (%)	61	60	83	72	67	68	65	70	58	66	82	71	69
1979													
Maximum air temp. (°C)	18.7	20.6	19.5	23.5	26	30	30.8	29.8	25.8	26.4	24	-	22.9
Minimum air temp. (°C)	11.6	10.3	10.9	12.1	15	14.1	20.4	21.8	17.7	13.4	14.2	-	14.9
Rainfall (mm)	4.3	1.6	-	-	-	-	-	-	-	1.1	-	11.3	18.3
Relative humidity (%)	65	68	70	68	72	72	71	71	71	69	-	-	70
1980													
Maximum air temp. (°C)	17.9	16.9	21	27.7	26.3	27.1	30.1	29.3	26.9	26.8	23	19	24.3
Minimum air temp. (°C)	9	8.6	9.3	12.9	14.7	13.4	23.3	20.3	19	16.8	13.9	10.3	14.3
Rainfall (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-
Relative humidity (%)	79	80	70	69	76	82	87	74.5	68	71	76	69	75
1981													
Maximum air temp. (°C)	16.6	18.4	21.9	25.7	26.4	29	29.6	30.4	28	28	21.9	21.1	24.7
Minimum air temp. (°C)	8.0	8.5	11.4	13.4	14.2	17.2	20.5	21.1	19.5	17.6	13.2	10.9	14.6
Rainfall (mm)	-	5.4	9.5	-	-	-	-	-	-	-	0.3	-	15.2
Relative humidity (%)	67	80	81	76	80	87	89	84	87	84	77	71	80

3.1.2. Hydrological conditions.

Ground water in the region occurs under both artesian and non-artesian conditions, however, all the ground water available for agricultural and domestic uses occurs in relatively shallow non-artesian aquifers. Large quantities of ground water are deeply seated in rocks ranging in age from cretaceous to miocene, but water is brackisk or highly saline.

3.1.2.1. Main water table : The main water table aquifer is composed primarily of relatively fine-grained marly limestone, but near the coast it is composed of alluvial silt and sand.

The surface of the main water table is at, or near, the sea level throughout most of the area. In some places such as at Dabaa, the water table is only 1 m above the mean sea level, 12 km south of the coast.

Recharge to the main water table occurs through direct infiltration of precipitation and through infiltration of surface runoff, particularly near the coast.

Discharge occurs through extraction from shallow wells, evapotranspiration where the water level is near the surface, and subsurface outflow to the sea.

a). Coastal dune water table : From Alexandria to El Alamein, the dunes are very prominent,but between El Alamein and Dabaa they are less conspicuous. Discharge of water from dunes occurs through galleries in El Qasr area, and through subsurface seepage to the sea and inland to the coastal depressions.

b). Synclinal basin water table : In some areas in the coastal zone the interbedded limestones and clays have been folded into gentle synclinal (basin like) structures. Where the relatively impermeable clay in such a basin is overlain by limestone and where the basin lies above sea level, conditions are favourable for the development of ground-water table. Such basins are recharged by rainfall, runoff or by subsurface inflow. The salinity of the water in the structural basins is lower than that of the other water table (FAO 1970).

3.1.2.2. Depth of water table : The depth of water table varies from less than a meter to more than 50 meters depending on the season and topography.

The highest water level occurs from February to April, depending on the length of rainy season, and the lowest water level occurs from October to November depending on the begining of the rainy season.

To the south of the area, wells with water deeper than 50 m are utilized by bedouins ; nearer to the coast, the water table is of course, closer to the surface. In the interdunal plain behind the coastal dunes, the water table is generally less than 5 m below the surface. In the coastal dunes, the water generally ranges from 5 to 10 m below the surface depending on the height of the dunes.

3.1.2.3. Quality of water : The quality of water in the several aquifers found in the area varies widely. Depending on the hydrogeological conditions, the content of dissolved solids may vary from a few hundred to several thousand parts/million. Water quality also varies with season, being best after winter rainfall and worst in late autumn before the begining of the rainy season.

3.1.3. Soil conditions.

The mapping of soils of El Omayed test-area in the present study was based on already published informations (ABD EL KADER *et al.* 1981 ; FAO 1970), analysis by photo-interpretation and through Landsat satellite imageries and the data collected in the field (ISMAIL *et al.*, in preparation, 1983).

Detailed pedological study of this area was realized at the scale of 1 : 25 000. Typical samples were collected and analysed for the most important elements. Other transects were studied using the same method to get sufficient information about the soils of the area and their spatial distribution. A preliminary soils map could then be established and compared with other cartographic documents which were already prepared particularly that of the vegetation. Another field study was carried out for checking and improving the preliminary map, by observation, sampling and complementary analysis.

With new observations, land determinations and analysis of some samples, the map of land resources was etablished. Finally, a field study carried out in cooperation with specialists from other disciplines enabled phytosociologists, agronomists and pedologists to compare the documents proposed by each team and to cross-check their observations.

3.1.3.1. Conditions of soil evolution.
The effect of climatic conditions, geomorphology, vegetation and human activities on the recent evolution of soil are dealt with elsewhere. Therefore, only a few important geological and geomorphological features are reviewed here.

Pedological evolution observed in El Omayed test-area is not simply the result of the evolution of soils. In fact, it started, a long time ago for most of the soils, and certainly under more active pedogenetic conditions. During that time, new littoral formations and lacustrine or lagoon sands and clay sands, often saline deposits were produced in the North. They were more or less modified by wind action. Eolian deposits are remodelled from various origins, often due to recent tectonic phenomena in proximity to the coast and close to the border of the Nile Delta.

3.1.3.2. Pedological units.

The pedological units (Fig. 6 & 7) are defined and grouped here on the basis of the French Pedological Classification System (CPCS, 1967). This system is of a morphogenetic type and, in the case of these dry zone soils seems well adapted to the present study, particularly when it is visualized from the management point of view (problems of saline soils, more or less hydromorphic soils ... etc). Also, the nomenclature of each unit in USDA Soil Taxonomy (1975) is given. The French classification of each unit is determined for the family level which is defined by the characteristics of the parent material of each soil and even for the serie level.

In the case of El Omayed test-area, it is necessary to lay stress on the origin of sand deposits, particularly those due to wind action, and on their lime content, in the upper horizons. Accordingly, three categories of soils may be distinguished : excessively calcareous soils containing more than 60 % carbonate (S") ; very calcareous soils, containing from 20 to 60 % carbonates (S') ; and calcareous soils with less than 20 % carbonates but, containing at least some calcareous elements (> 2 to 3 %) (S).

The soils are classified as it follows :

a) Raw mineral soils

These are formed of more or less weathered rock at the surface ; the differentiation of horizons is very limited. They are very poor in organic matter. In El Omayed test-area, they are of non-climatic origin, but the aridity conditions of their formation do not foster their evolution. They are formed by the following two processes :

. Erosion : this process is the main factor causing the slowing down of the evolution in the case of the soils formed from the consolidated calcareous oolitic dunes. They are Lithic Torriorthents ; they do not have practical agricultural value.

. Addition : from eolian and colluvial sand, chiefly along the inland ridges. The soils are moderately thick to deep, and the addition process is still, more or less, regularly active. They may be constituted by excessively calcareous medium, and coarse sand (S") ; they are very dry. Others are constituted by very calcareous elements (but less calcareous than the previous ones and often of finer texture). Their hydrologic characteristics are not so bad. In this case as in the other one, they are named "Typic Torripsamments" ; they may be useful for agriculture.

b) Slightly evolved soils

. Modal grey sub-desertic soils : These already exhibit some slight differentiation of horizons. This is mostly demonstrated through their physical properties (porosity and induration in particular) and by the relative distribution of saline elements through their profile. The content of these elements is often relatively higher at the surface, sometimes calcium carbonates and gypsum which may accumulate in depth but only in pseudo-

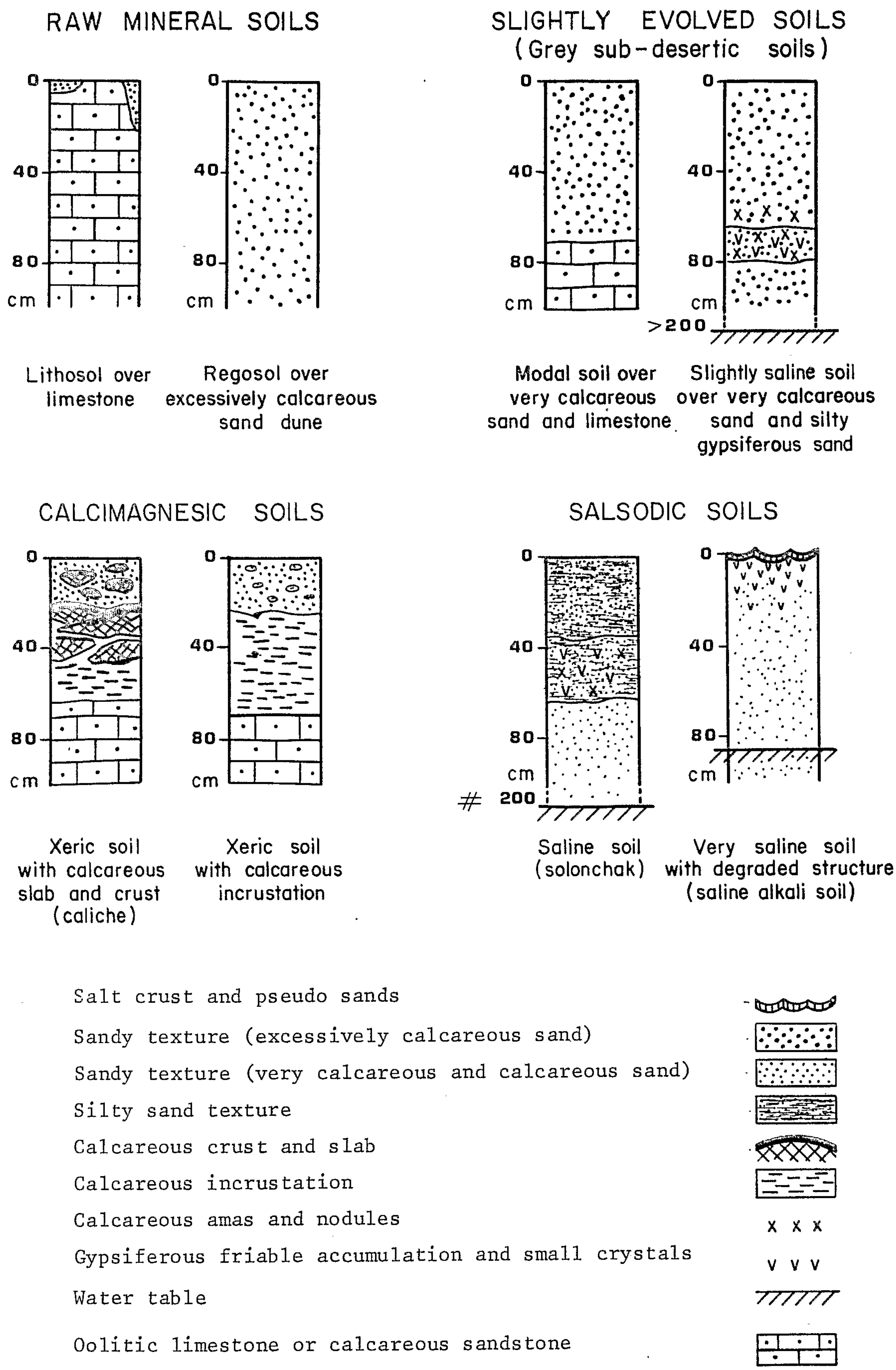
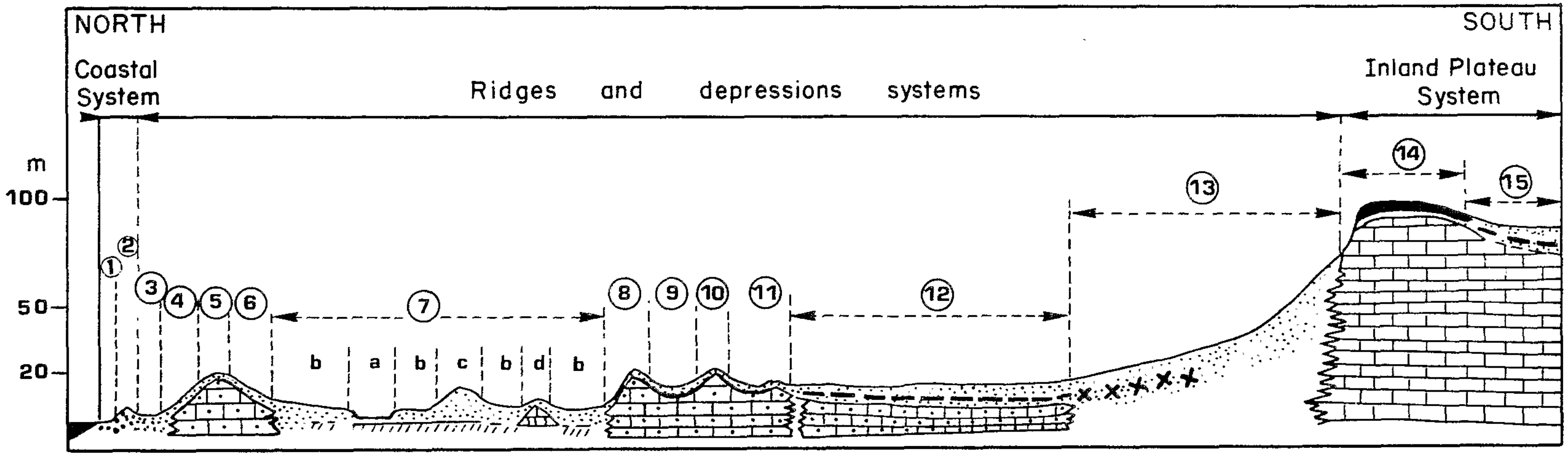


Figure 6 - MAIN SOIL PROFILES



Physiographic units

COASTAL SYSTEM
- 1 - Beach
- 2 - Coastal sand dune

RIDGES AND DEPRESSIONS SYSTEMS
- 3 - First depression
- 4 - Northern slope of first rocky ridge
- 5 - First rocky ridge (1 RR)
- 6 - Southern slope of first rocky ridge
  - a) salt marsh
  - b) hummocky depression
  - c) sandy meso deposits
  - d) sandy indurated convexities
- 7 - Saline depression
- 8 - Second rocky ridge (2 RR)
- 9 - Inter-ridges sandy slopes
- 10 - Third rocky ridge (3 RR)
- 11 - Southern sandy slopes
- 12 - Non saline depression
- 13 - Sandy glacis (gullies)

INLAND PLATEAU SYSTEM
- 14 - Cliff and outcroup of Inland plateau
- 15 - Undulating sandy surface

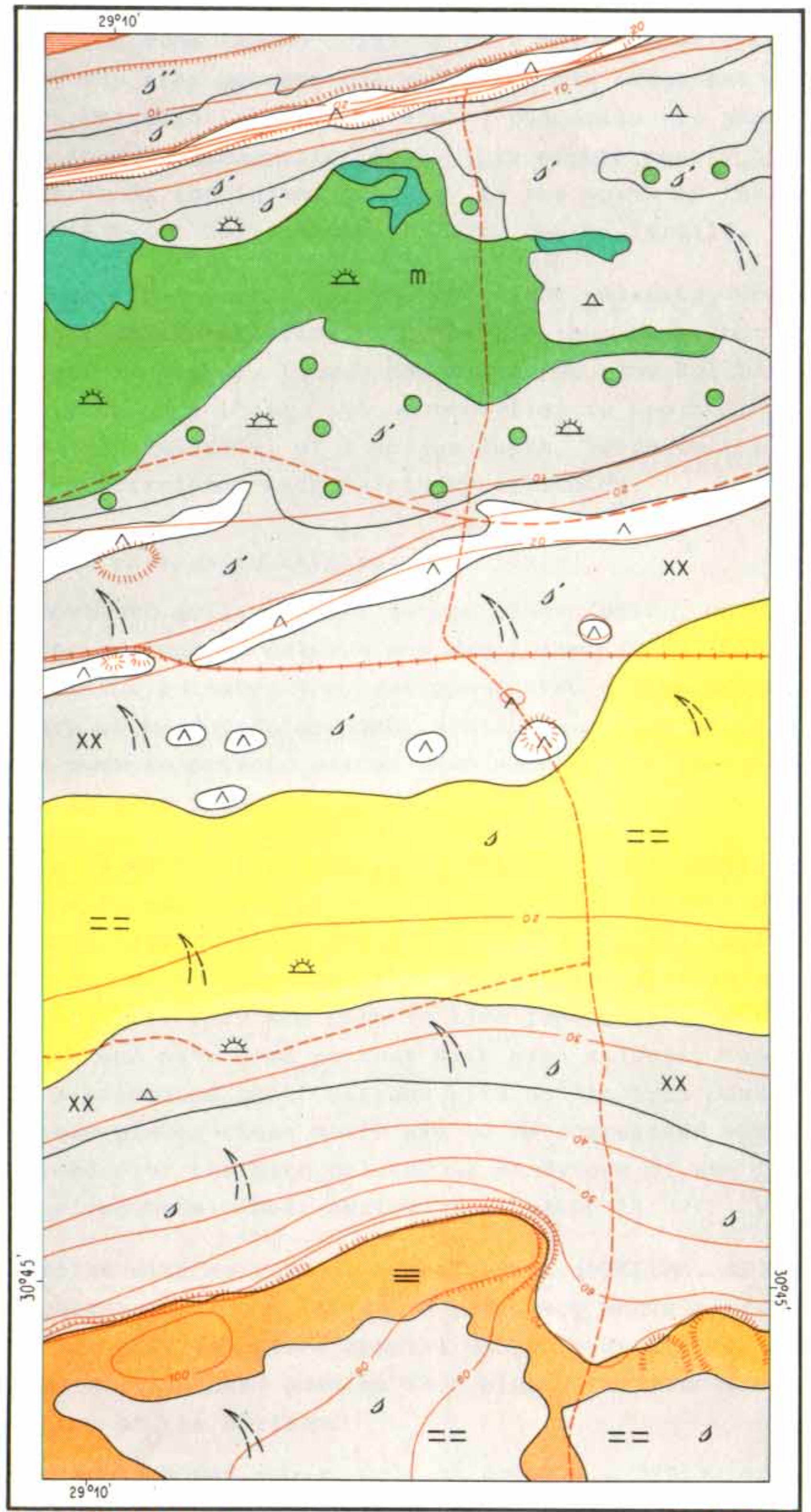
Pedological features

- Excessively calcareous sand
- Very calcareous and calcareous sand
- Calcareous amas and nodules
- Calcareous incrustation
- Calcareous slab
- Water table
- More or less oolitic limestone
- Calcareous sandstone

Figure 7 - PHYSIOGRAPHIC UNITS AND PEDOLOGICAL FEATURES OF EL OMAYED (SCHMATIC)

SOIL MAP

EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E. L. Emberger.

Scale 1: 50 000

Contour interval : 10 m

Figure 8

LEGEND

SOIL CLASSIFICATION OF THE DIFFERENT UNITS OF THE MAP (BASED ON FRENCH SOIL CLASSIFICATION AND USA SOIL TAXONOMY)

Class	Sub-Class	Group	Sub-Group	Family	U.S.A. Soil Taxonomy	Representation
Raw mineral soils	Non climatic	by erosion	Lithosols	Over limestone (consolidated oolitic dunes)	Lithic torriorthents	Λ
		by addition	Eolian	Over excessively calcareous sand dune and actual oolitic dunes	Typic torripsaments	
Slightly evolved soils	Climatic	Grey sub-desertic soils (xeric)	Modal (locally, moderately deep lime accumulation in amas and nodules) sometimes associated with calcimagnesic soils	1) Over very calcareous sand from mixed origin a. colluvial from consolidated oolitic dunes b. eolian from continental sand 2. Over calcareous sand, essentially from continental origin	Typic torripsaments	
			With salinity properties (saline)	Over very calcareous sand from a mixed origin and silty gypsiferous sand	Calcic gypsiorthids	●
Calcimagnesic soils	Carbonated	Xeric	With calcareous slab and locally saline by patches	Over hard calcareous sandstone	Typic paleorthids	≡
			With calcareous incrustation and often salt-affected in depth	Over sand and marine calcareous sandstone	Typic calciorthids	= =
Salsodic soils	Soils with non-degraded structure	Solonchaks with calcimagnesic complex (Ca - Mg)	Saline soils, with friable surface	Over calcareous silty sand and shelly clayey sand	Typic calciorthids	
	Soils with degraded structure	Non-leached	Very saline alcali hydromorphic soil, with friable surface, gypsum thin crust or pseudo-sand by places	Over very calcareous sand and shelly clayey sand	Typic salorthids	

SYMBOLS OF THE PEDOLOGICAL FEATURES

PARENT MATERIAL

Λ Limestone (consolidated oolitic dune)

TEXTURE :

Sandy texture (calcareous sand)

' Sandy texture (very calcareous sand)

'' Sandy texture (excessively calcareous sand)

m Silty sand texture (to sandy silt)

THE MORPHOLOGY OF THE SURFACE

Wind blown sand

Hummocks

△ More or less stabilized microdunes (0.5-1 m high)

PEDOLOGICAL INDICATIONS

XX Calcareous amas and nodules

= = Calcareous incrustation

≡ Calcareous crust (caliche) and slab

mycelium, friable amas and nodule forms (POUGET, 1980). Sometimes in El Omayed area there are some intergrades between these soils and either less poor in organic matter sierozems or calcimagnesic soils.

Most often they are thick (1-1,5 m), but may overlay more or less saline clay deposits from lagoon origin ; this may be mostly observed in the northern part of the area between the ridges of old indurated coastal oolitic calcareous dunes. Particularly to the south, the soils are sometimes associated in patches with some calcimagnesic soils. This occurs mostly over the sandy glacis which surrounds the inland plateau, to the south of the test-area. Here also the soils are Typic Torripsamments. They can be fertile.

. Grey sub-desertic soils with slight salinity. These soils are analogous in their characteristics with the previous ones, but their salts and gypsum content is higher, though not excessive. The soluble salts accumulated at the surface, but their high content lies in depth from where they come. The gypsum accumulation, at a medium depth, leads to the formation of amas. They may be correlated with Calcic gypsiorthids.

c) Xeric carbonated calcimagnesic soils

These evolved soils exhibit a type of evolution, which is strongly dominated by high content of calcium and magnesium. In El Omayed area, they are calcareous at the surface. They contain a strong lime accumulation in depth in the form of hard nodules, incrustation and even caliche or slab. They are not so poor in organic matter than most of the previous ones and their structure is also stable.

. Soils with calcareous slab. These are thin soils, mostly 15 to 30 cm deep to the calcareous crust or slab, and more or less splitting at their base (POUGET, 1980). Their evolution started in the Early Quaternary, but is still going on. Through that thickness, their organic matter content may be up to 0.8 - 1 %. They are rich in lime fragments from the calcareous crust or the slab and have some patches with high salinity. In these patches soils may give a saturated paste extract with an electric conductivity up to 50 mmhos. In these places these soils are to be correlated with salsodic soils. They spread over the hard calcareous sandstone of the inland plateau, and are Typic paleorthids. Their agricultural value is very limited.

. Soils with calcareous incrustation (RUELLAN, 1970). In El Omayed test-area the calcareous accumulation is also very ancient; it may be from the Middle Quaternary. They exhibit a special characteristic to the deepest horizons of the soil : large hard nodules in a highly calcareous matrix without complete hardening of the horizon.

This processes may appear only at about 1 m depth, or sometimes near the surface (20-50 cm). Very often they are slightly saline at medium depth, but in their deepest horizons they may form a saturated paste extract with a conductivity as high as 15 mmhos. Therefore they may be classified in a slightly saline soils subgroup.

They mostly develop in the "inter-ridges" zone between the dissected old indurated coastal dunes and the sandy glacis bordering the inland plateau scarp. They also extend further south.

Both soil types, being slightly salf-affected or not, are Typic calciorthids. Their fertility level, in most cases is medium ; but sometimes is low, depending on the thickness of horizons over B_{ca} and on salinity.

d) Salsodic soils (AUBERT, 1975)

These soils have a high content of soluble salts (conductivity in saturated paste extract more than 8 mmhos for the surface, and more than 16 mmhos in depth). Some of them retain a stable structure, while others do not, at least in a great part of their profile, where their structure becomes diffuse through the effect of sodium.

. Salt-affected (saline) soils with a non-degraded structure. These are derived from calcareous silty sands, over saline clay sands rich in shell detritus. The last material has a lagoon origin. Their salt profile is descendent or intermediate. They are very calcareous at the surface, and have a lime accumulation at a medium depth. Sometimes also, the same process plays a role at the surface, but only slightly. Even with an unstable structure when humid, they are relatively well drained. They are also Typic calciorthids.

They extend in the northern depression between the two indurated coastal dunes. Because of their low position, they would be very difficult to drain and to manage for agriculture.

. Very saline alkali-soils. The structure of these soils is degraded from the surface because of their high content of exchangeable sodium. They also are very rich in sodic soluble salts (chlorides and sulphates). Here and there, mostly around nebkhas, the surface is transformed into pseudosand ; somewhere else it is covered by a thin crust of salts with a gypsum pseudomycelium. In other parts of its profile, the soil is compact and massive, mostly less below 75 cm deep where it becomes more and more clayey ; its structure becomes strictly diffuse. These soils are mostly hydromorphic in depth. Their salt profile is ascendant, and they are very calcareous. They are Typic salorthids.

The surface where they are observed is not very extended, except in the elongated lowest part of the northern depression between the indurated coastal dunes. Practically they have no economic value, mostly because their drainage would be too difficult and their desalinisation would need too much water.

3.1.3.3. Other informations shown on the map.

By some additionnal signs, the map (Fig. 8) shows the following :

. Special soils parent-materials. These are indurated calcareous oolitic sandstone of the coastal dunes, and clay sand with gypsum crystals.

These characteristics are used in the soil classification at the family level.

. Some aspects of the surface morphology, in the form of superficial cover of wind blown sand, nebkhas, and more or less stabilized microdunes.

. Soil texture : in the soil classification it is used at the family level. The map shows in particular the excessively calcareous, very calcareous, and moderately-weakly calcareous sandy soils, and of soils of finer texture mostly silty or seldom silty clay.

. Special pedological characteristics, which correspond to various types of accumulation of saline or calcareous elements.

3.1.4. Land use and Plant Cover (natural and artificial)

The vegetation of the "western coastal region" of EGYPT has been extensively studied since the papers of OLIVER in 1937 (ATTA 1953 ; TADROS 1953 ; LONG 1955 ; TADROS and ATTA 1958 ; AYYAD 1973 ; AYYAD and AMMAR 1974 ; AYYAD 1976 ; KASSAS 1979 ...).

From the phytogeographic and floristic point of view this region is referred to as the Marmarica region. It is estimated that (about 1000 species) approximatively 50 % of the Egyptian flora is found in this region. It has a long history of human pressure which has been so heavy in the past that with only a few exceptions, all spontaneous flora is represented by small shrubs and herbs. Very few shrub species which are either very rare or only found in sites with extreme environmental conditions (high salinity and water logging) are found in this region (e.g. *Tamarix* sp.). Some individuals of a few species may grow up to more than two meters in height (e.g. some *Atriplex* sp., some *Lycium* sp., *Nitraria retusa*). The human activities have gradually eliminated all the tall plants. When establishing a land cover map, human interference has to be considered as an important ecological factor, which influences the present state of the vegetation and cultivation.

3.1.4.1. Land cover.

The land cover map provides a combination of the present state of plant cover (natural vegetation and cultivated plants) and the degree of artificialization which represents the level of the human pressure upon land resources. The procedure and legend used in building up such a map have already been described in details for this part of EGYPT (LONG, 1979 ; LE FLOC'H 1979, 1981). A short description of this procedure will be presented here. It consists of an objective and quick description of isophenic areas (described for their various features) as they are delineated on aerial photographs and then checked in the field. These features are mainly related to :

- the present state of vegetation (e.g. type of plant formation, dominant species), and
- the degree of artificialization.

a) Designation and coding of dominant plants leading to the physiognomy of vegetation.

The coding is proposed in categories considering the height and the cover of dominant growth forms of plants :

- ligneous : . tall (height > 2 m) = LH
  . low (height < 2 m) = LB
- herbaceous : = H

The plant formations characterised by the dominance of one or the other of these plant forms are qualified as pure plant formations. The ones in which codominance of different plant forms prevails are considered as complex plant formations. This rule is applied to natural vegetation as well as to cultivated plant systems.

b) Designation and coding of the degree of artificialization.

The criterion of "degree of artificialization", expressed as a relative value of the human pressure on land, may be considered as a very important ecological factor. The degree of human pressure is "nil" or "low" where resources are not important (e.g. in areas of high salinity) and in more favourable areas which are not accessible because of long distance from human settlements. On the other hand the pressure can be "very high" close to human settlements, along the roads, or near the watering points, and obviously in cultivated lands. It is conceivable that in expressing the level of human pressure due to his activities, the degree of artificialization does not necessarily assess the impact of such activities, but is rather an expression of the criteria combining human activities as related to the fragility or vulnerability of the ecosystems (see section 3.3).

c) Designation and coding of dominant species.

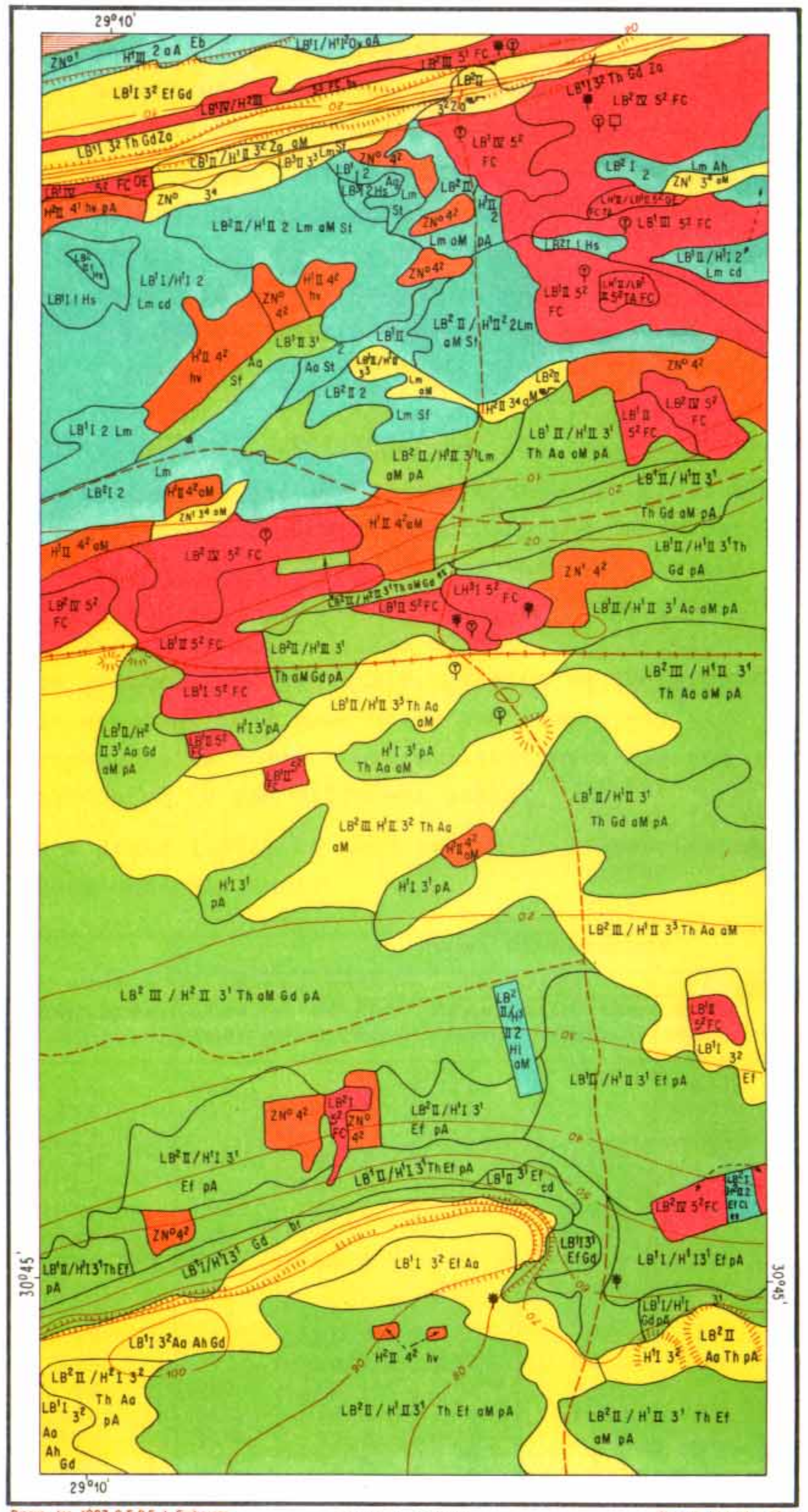
Dominant species are coded with two letters symbolizing their scientific names, as reported in "Students Flora of EGYPT" by V. TÄCKHOLM (1974). The dominant species are those which designate the "plant formations", as described in section *a)* of this chapter. If one or two species which seem to be dominant are widely and uniformly distributed, it may be advisable to code not only the dominant and the codominant species, but also the third and fourth ones which, in some cases, exhibit the highest ecological significance. Some isolated individuals whose presence is obviously significant visualising the potential vegetation are located with accuracy on map and represented with specific symbols.

d) Identification and coding of isophene units on the land cover map.

The combination of codes for plant formations, for the degree of artificialization, and for dominant species provides a comprehensive description of the isophene units (Fig. 9). The brief legend along with the land cover map facilitates the reading of the codes which describe every unit ; for example :

LAND COVER MAP

EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E.L. Emberger — Scale 1:50 000 — Contour interval : 10 m

Figure 9

LEGEND

CODIFICATION OF EXISTING [redacted] PLANT FORMATIONS

Designation of the main plant formations	Cover in % tall ligneous	low ligneous	herbaceous	Code
BARE UNITS Bare soil, without vegetation or with very sparce vegetation	0 0 - 1	0 0 - 5	0 0 - 5	ZN^0 ZN^1
PURE PLANT FORMATIONS Tall pure ligneous plant formations	1 - 5 10 - 25	0 - 1 0 - 1	0 - 5 0 - 5	LH^1 LH^3
Low pure ligneous plant formations	0 - 1 0 - 1 0 - 1	5 - 10 10 - 25 25 - 50	0 - 5 0 - 5 0 - 5	LB^1 LB^2 LB^3
Pure herbaceous plant formations	0 - 1 0 - 1	0 - 5 0 - 5	5 - 10 10 - 25	H^1 H^2
COMPLEX PLANT FORMATIONS	They are designated by combining the constituent pure plant formation's codes.			

Code of the height classes

	0 – 0,10m	0,10m – 0,25m	0,25m – 0,50m	0,50m – 1m	1m – 2m	2m – 4m	4m – 8m
tall ligneous (LH)						LH I	LH II
low ligneous (LB)	LB I	LB I	LB II	LB III	LB IV		
herbaceous (H)	H I	H II	H III	H III			

CODIFICATION OF EXISTING DOMINANT SPECIES

tall ligneous species — low ligneous species

Latin name	English name	Symbol for isolated trees	Code	Latin name	Code	Latin name	Code
Ficus carica	fig		FC	*Anabasis articulata*	Aa	*Helianthemum lippii*	Hl
Nicotiana glauca			NG	*Atriplex halimus*	Ah	*Limoniastrum monopetalum*	Lm
Olea europaea	olive		OE	*Convolvulus lanatus*	Cl	*Ononis vaginalis*	Ov
Phoenix dactylifera	date palm		PD	*Crucianella maritima*	Cm	*Salicornia fruticosa*	Sf
Tamarix articulata			TA	*Echiochilon fruticosum*	Ef	*Salsola tetrandra*	St
				Gymnocarpos decandrum	Gd	*Thymelaea hirsuta*	Th
				Halocnemum strobilaceum	Hs	*Zygophyllum album*	Za

NB : *Ficus carica* which often appears like a low ligneous species has nevertheless to be codified as tall ligneous : FC

herbaceous species (perennial / annual)

Latin name (perennial)	Code	Latin name (perennial)	Code	Latin name (annual)	Code
Ammophila arenaria	aA	*Echinops spinosissimum*	eS	*Bromus rubens*	br
Asphodelus microcarpus	aM	*Plantago albicans*	pA	*Cutandia dichotoma*	cd
Euphorbia paralias	eP			*Hordeum vulgare (cultivated)*	hv

CODIFICATION OF EXISTING [redacted] DEGREES OF ARTIFICIALIZATION

RANGELANDS

Steppic vegetation in good balance.

- Vegetation and habitat weakly influenced by man : gathering of plant for traditional uses ; exceptional grazing. — 1
- Rangelands in a relatively good balance. — 2

Steppic vegetation overgrazed with capability for regeneration after short period of protection.

- Overuse of the herbaceous plant cover and of low palatable ligneous shrubs — 3^1

Steppic vegetation overgrazed without real capabilities of natural regeneration

- The herbaceous plant cover has been almost eliminated. Browsing of low palatable shrubs, excess of trampling and effects of erosion are observed — 3^2
- Neither edible plant production, nor standing reserve for regeneration do remain — 3^3
- All woody species around human settlements have been destroyed. Species as *Asphodelus microcarpus* can appear for a short period — 3^4

VEGETATION INTRODUCED BY MAN

- Traditional crops (mainly barley) — 4^1
- Mechanized crops (mainly barley) — 4^2
- Olive, figs, almonds with little care (rare cropping and protection) — 5^1
- Orchards well cultivated (regular ploughing, pruning, and manuring) — 5^2
- Rainfed arboriculture combined with a rainfed annual intercalary crop (barley ...) — 5^3

H^{1}II4^{2}hv means : rainfed winter barley (hv) with traditional cropping system ; low plant cover (5-10 %) and 10-25 cm height of crop.

LB^{2}IV5^{2}FC means: orchard of fig trees (FC) with regular ploughings ; plant cover : 10-25 % ; height of orchard : 1-2 m.

LB^{1}12Lm means: rangeland of low ligneous plants ; plant cover : 5-10 % ; height of plant:0-25 cm ; grazing is light. The main dominant species is *Limoniastrum monopetalum* (Lm).

LB^{2}III/H^{1}II3^{2}Th,Aa,aM means : rangeland with low ligneous and herbaceous plants. The low ligneous plant cover : 10-25 %, with 0.5-1 m height. The herbaceous cover : 5-10 %, with 10-25 cm height. This unit is overgrazed ; many edible plants are eliminated. The dominant species are : *Thymelaea hirsuta* (Th), *Anabasis articulata* (Aa) and *Asphodelus microcarpus* (aM).

c) Quantification of the types of land use in the test-area.

The units located and identified in the map provide a means of quantifying relative areas. The results concerning the different types of land use (Table 8) expressed in the framework of the physiographic map (Fig. 3) show very well that human action is an important ecological factor, and that a more accurate analysis of the degree of artificialization is needed for its evaluation (see sections 3.2. and 3.3.). Grazing is the predominant land use type, but it is apparent that some units are completely under cultivation (e.g. physiographic units 3 and 7 c), and that orchards and cropping areas are already introduced in ten different units.

Table 8. Present state (1981) of land use in El Omayed test-area according to the physiographic units.

Coded units as shown in fig.3	area (hectares)	Types of land use					
		Rangelands		Orchards		Cropping area	
		area (ha)	% of the unit	area (ha)	% of the unit	area (ha)	% of the unit
1	17	nil		nil		nil	
2	126	92	73	34	27	0	
3	27			14.5	53.7	12.5	46.3
4	34	18.5	54.4	15.5	44.1		
5	62	62	100				
6	102	64	62.7	27	26.5	11	10.8
7a	60	60	100				
7b	844	680	80.6	44	5.2	120	14.2
7c	219			219	100		
7d	9	9	100				
8	27	27	100				
9	316	77	24.4	177	56	62	19.6
10	98	98	100				
11	504	389	77.2	88	17.5	27	5.3
12	927	905	97.6	13	1.4	9	1
13	934	874	93.6	29	3.1	31	3.3
14	276	276	100				
15	408	408	100				
TOTAL (hectares)	4990	4039.5		661		272.5	

An analysis of the present state of degree of artificialization is presented in the Table 9.

Table 9. Analysis of the present state of different criteria of the degree of artificialization in El Omayed test-area (1981).

<u>Rangelands</u> (degrees 1 to 3^{4} included) 4072 hectares, 81.4 % of the area

- * steppic vegetation in good balance (undergrazed and not grazed) 701 hectares
  - Δ degree 1 : forbiden area along seashore, high salinity vegetation : 53 hectares
  - Δ degree 2 : saline depression : 648 hectares
- * steppic vegetation overgrazed : 3371 hectares
  - . steppic vegetation with capability of regeneration after some months of protection against grazing
    - Δ degree 3^{1} : rangelands 4 km from the seashore to inland, the most important in the area : 2218 hectares
  - . steppic vegetation without or with very low capabilities of natural regeneration
    - Δ degree 3^{2} : around rigdes — 869 hectares
    - Δ degree 3^{3} : around Omayed station — 241 hectares
    - Δ degree 3^{4} : around sedentarization areas — 43 hectares

<u>Vegetation introduced by man</u> (degrees 4^{1} to 5^{3}) 918 hectares : 18.4 % of the area

- * herbaceous vegetation without irrigation, cereal crops : 253 hectares
  - Δ degree 4^{1} : narrow fields along the first rocky ridge — 11 hectares
  - Δ degree 4^{2} : almost of barley fields in the area sometimes bare surfaces during dry year — 242 hectares
- * orchards trees plantations in rainfed condition : 665 hectares
  - Δ degree 5^{1} : figs with little care — 27 hectares
  - Δ degree 5^{2} : figs mostly, some olives, rare almonds — 620 hectares
  - Δ degree 5^{3} : figs plantation with barley as intercalary crop — 18 hectares

This table also aims at explaining our choice of colour for this theme on the land cover map :

- rangelands are in dark pale green and yellow :
  - . dark-green for steppic vegetation in good balance; it covers 14 % of the area ;
  - . pale green for steppic overgrazed vegetation out with capability of regeneration after some period of protection ; that is 44.5 % of the area ;
  - . yellow for steppic vegetation without capability of natural regeneration ; surface : 23 % of the area ;
- vegetation introduced by man is in orange and red colours :
  - . cropping area is in orange (approximatively 5 % of the area) ;
  - . orchards in rainfed conditions are in red, and cover about 13 % of the area.

3.1.4.2. Plant ecological relationships.

The analysis of the Mediterranean flora and the classification of the phytogeographical sub-divisions of North Africa by QUEZEL (1978), indicate that the flora of the western Mediterranean coastal region of Egypt belongs to the "Steppic Eastern-African Domain", of the "East Mediterranean subregion". The Mediterranean region is classified as a part of the "Mesogean subkingdom" of the "Holarctic kingdom".

a) General phytosociological and phytoecological survey of the western Mediterranean coastal region of Egypt.

The flora of the western Mediterranean coastal region of Egypt is a product of climatic changes that occurred during the Pleistocene as well as a long history of land use. The distribution of plant communities is controlled by the topographic location, the origin and nature of parent soil material, and the level of the human pressure. According to previous studies (e.g. TADROS & ATTA 1958) we may recognize the following communities in the uncultivated areas :

- *Plantagineto - Asphodelaetum microcarpae*
- *Thymelaetum hirsutae*
- *Asphodelaetum microcarpae.*

In barley fields, and more generally in all cultivated fields, we may recognize a community of *Achilleatum santolinae mareoticum.*

Five main types of habitat may be distinguished in the western Mediterranean coastal region of Egypt, each supporting specific communities : coastal calcareous dunes , inland ridges with skeletal shallow soils, saline marshy depressions , non-saline depressions and inland plateau.

The coarse loose nature of sand and the extremely high carbonate content are the major features of the habitat of coastal dunes. It is characterized by marked physiographic heterogeneity which leads to distinct local variations in the distribution of vegetation and presents a variable environment due to changing stability of the dunes. The vegetation is generally distinguished into a community of *Ammophila arenaria* and *Euphorbia paralias* on young dunes, and *Crucianella maritima* and *Ononis vaginalis* on old dunes (TADROS 1956, TADROS & ATTA 1958). At the initial stage of formation, the dunes are unstable and are overwhelmigly dominated by a community of *Ammophila arenaria.* In more advanced stages of dune stabilization, communities of *Euphorbia paralias*, *Pancratium maritimum*, *Elymus farctus*, *Crucianella maritima*, *Echinops spinosissimus* and *Thymelaea hirsuta* become successively more and more common. (KAMAL 1982).

The inland siliceous sands are dominated by communities of *Plantago albicans*, *Plantago squarrosa* and *Urginea maritima* (MIGAHID *et al.* 1975).

The classification of the vegetation of inland ridges and similar areas of shallow soils along the western Mediterranean coast of Egypt has been dealt with by TADROS & ATTA (1958). Two associations are recognized :

one codominated by *Thymelaea hirsuta* and *Gymnocarpos decandrum* (*Thymelaeatum hirsutae*), and the other by *Plantago albicans* and *Asphodelus microcarpus* (*Asphodelaetum microcarpae*). However, local variations in the nature of surface, soil texture, and slope position and degree, effectuate parallel variations in vegetation distribution. The most rocky sites with the lowest moisture availability are dominated by communities of *Thymus capitatus*, *Globularia arabica* and *Dactylis glomerata* (KAMAL 1982), while sites with more or less deep soils and high moisture availability are dominated by communities of *Asphodelus microcarpus*, *Herniaria hemistemon*, *Plantago albicans* and *Salvia lanigera*. In sites of intermediate rockiness and moisture availability *Gymnocarpos decandrum*, *Anabasis articulata*, *Helianthemum lippii*, *Scorzonera alexandrina* and *Pituranthos tortuosus* become more common (AYYAD & AMMAR 1974, KAMAL 1982). The communities which dominate the inland ridges extend their occurence to the plateau of the southern tableland, and two other communities dominated by *Hammada scoparia* and *Anabasis articulata* are found on degraded shallow skeletal soils (MIGAHID *et al.* 1975, KAMAL 1982).

The halophilous vegetation belongs to the alliances of *Plantaginion crassifoliae* and *Salicornion fruticosae* of typical saline and marshy habitats (TADROS 1953), *Salsolion tetrandrae* of habitats with soils derived from chalky rocks, and marls rich in gypsum and soluble salts (ZOHARY 1973), and *Anabasion articulatae arenarium*, *Hammada-Anabasion articulatae*, and *Thymelaeion hirsutae* of progressively less saline habitats (TADROS & ATTA 1958). These alliances include communities dominated by *Salicornia fruticosa*, *Cressa cretica*, *Atriplex halimus*, *Juncus rigidus*, *Arthrocnemum glaucum* and *Limonium echioides* in sites of high salinity and very shallow water table, *Suaeda monoica*, *Zygophyllum album*, *Limoniastrum monopetalum*, *Aeluropus lagopoides*, *Salsola tetrandra* and *Frankenia revoluta* in sites with relatively deep water-table but high salinity, *Atriplex halimus*, *Hammada scoparia*, and *Anabasis articulata* in sites with deep water table and relatively low salinity (AYYAD 1976). The vegetation of saline depressions is classified by AYYAD & EL-GHAREEB (1982) in the following indicator groups :

A. Groups of typical marshy habitat:

1. *Salicornia fruticosa*
2. *Cressa cretica*
3. *Atiplex halimus*
4. *Arthrocnemum glaucum* & *Halocnemum strobilaceum*

B. Groups in areas where the water table is one meter deep and of intermediate level of salinity:

1. *Arthrocnemum glaucum*
2. *Zygophyllum album*
3. *Limoniastrum monopetalum*
4. *Aeluropus lagopoides*
5. *Salsola tetrandra*

C. Groups in areas where the water table is deeper than one meter and of low salinity

1. *Thymelaea hirsuta*
2. *Hammada scoparia*
3. *Anabasis articulata*
4. *Asphodelus microcarpus*
5. *Plantago albicans*

The vegetation of non-saline depressions belongs to the *Plantagineto-Asphodeletum microcarpae* association (TADROS & ATTA 1958). Four communities are recognized : *Anabasis articulata* community on more or less sandy soils with low contents of $CaCO_3$, *Zygophyllum album* community where the soil content of $CaCO_3$ and salinity become relatively higher, *Plantago albicans* community where salinity becomes lower, and *Asphodelus microcarpus* - *Thymelaea hirsuta* community on fine-textured soils (AYYAD 1976). Non-saline depressions as well as catchment areas opposite to wadis provide favourable conditions for cultivation of barley, figs and olives. Farming operations stimulate the growth of a considerable number of species, mostly therophytes. The weed flora is fairly homogeneous and form a definite association : *Achileatum santolinae mareoticum*, with two sub-associations : (1) *Chrysanthemum coronarium* (*Chrysanthemetosum*) and (2) *Arisarum vulgare* (*Arisaretosum*) (TADROS & ATTA 1958).

In the habitat of inland plateau the following communities may be identified (KAMAL 1982) :

1. *Artemisia monosperma* and *Hammada elegans* community in inland less calcareous sites ;
2. *Anabasis articulata* and *Hammada scoparia* community in sites with shallow degraded soils ;
3. *Suaeda pruinosa* and *Salsola tetrandra* community in sites of more saline soils.

b) Phytoecology of El Omayed area

The vegetation of El Omayed was analyzed in 56 stands distributed along one transect from shore inland. The number of perennials encountered in this transect was 66 species, of which 15 were recorded in at least half of the 56 stands. Of these species *Gymnocarpos decandrum*, *Asphodelus microcarpus*, *Thymelaea hirsuta*, *Pituranthos tortuosus*, and *Plantago albicans* were the most common ; next to these were *Allium roseum*, *Noaea mucronata*, *Anabasis articulata*, *Launaea nudicaulis*, and *Lycium europaeum*. Non of these common species can be considered as a leading dominant, but some of them may dominate or share dominance in certain habitats of the topographic gradient of El Omayed area. For example, *Asphodelus microcarpus* and *Anabasis articulata* dominate the habitat of non-saline depressions. *Thymeleae hirsuta* and *Plantago albicans* dominate the habitat of rocky ridges and transitional area to ridges. On the other hand, some species dominate specific types of habitat (i.e. exhibit narrow ecological amplitudes). For example *Ammophila arenaria* dominates only the habitat of coastal dunes.

The groups and subgroups of species identified according to the indicator species analysis technique exhibit a clear relationship to habitats and transitional areas : *Gymnocarpos decandrum*, *Thymelaea hirsuta*, *Noaea mucronata* and *Pituranthos tortuosus* are indicators for the group of stands of all other habitats.

Ammophila arenaria and *Ononis vaginalis* are indicator species of the coastal dune habitat, *Halocnemum strobilaceum*, *Limoniastrum monopetalum* and *Frankenia revoluta* are indicator species for a group of stands characterizing the habitat of saline depressions ; *Artemisia monosperma* is an indicator species for the group of stands characterizing the nonsaline depressions; and *Herniaria hemistemon* and *Scorzonera alexandrina* are indicator species for the group of stands characterizing the rocky ridge habitat.

The communities in the main habitats that are recognized so far may be arranged in a general hierarchical system. The hierarchy which appears in the legend of the phytoecological map of El-Omayed (Fig. 10) is an adapted part of the general system constructed for the whole region by KAMAL (1982). This map is a specific version of the land cover map (see Fig. 9).

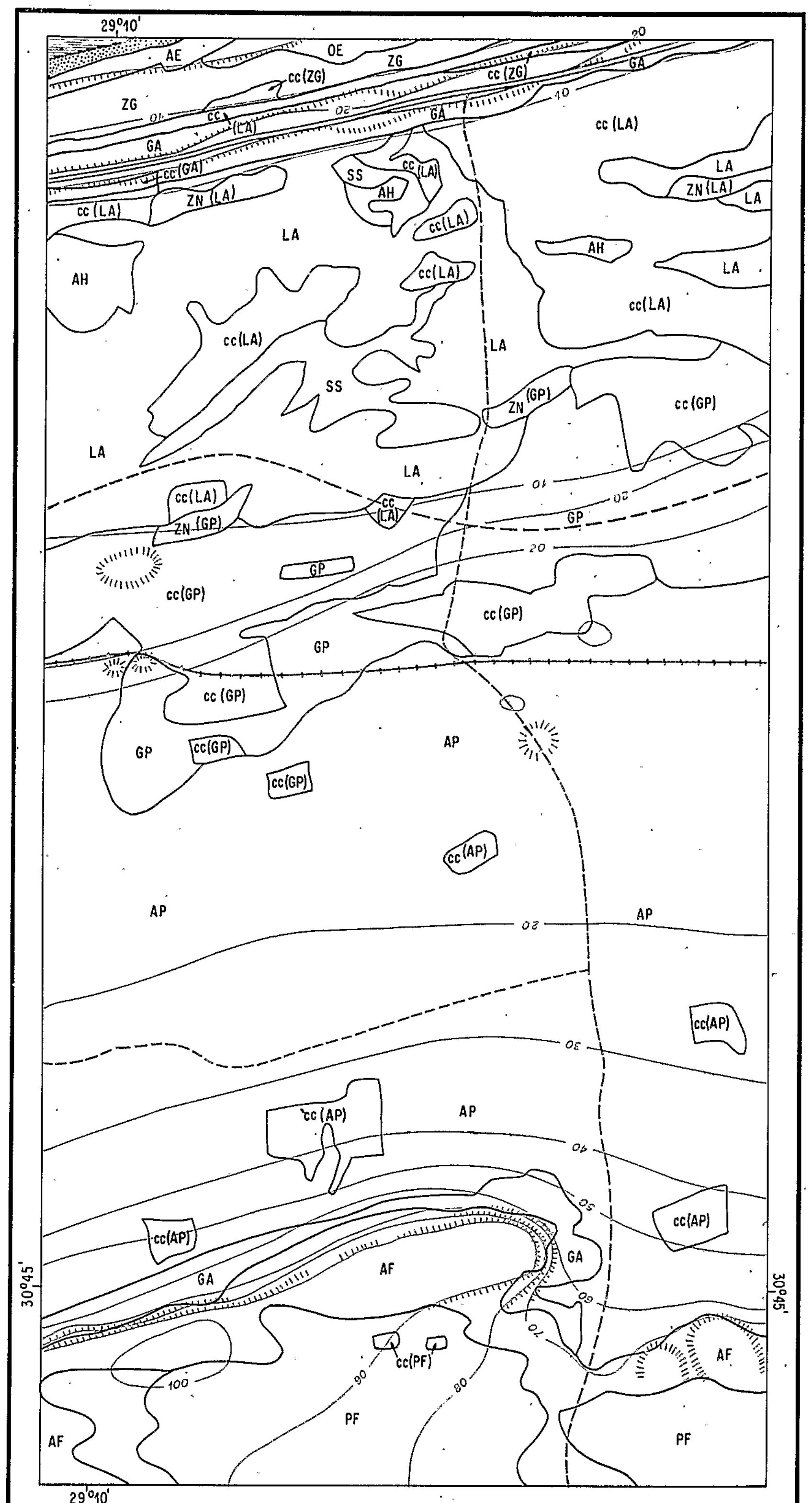
Note : It is clear that the presence of *Plantago albicans* as a dominant species for several sub-associations of rangelands can be explained by the fact that the trampling of animals remove the upper layer of the soil surface and this stimulates the growth of psammophytic species. These species, and particularly *Plantago albicans*, are also overgrazed, so their abundance or their scarcity can be used as an indicator of the level of overgrazing.

3.1.4.3. Vegetation dynamics.

Autogenic vegetational succession is, apart from building phytogenic mounds and hillocks, of little significance in deserts. Allogenic succession is one of the keys for understanding desert vegetation : successive waves of plant growth occupy an area due to gradual and cumulative changes in habitat produced by physical processes (KASSAS 1971). Progressive succession is primarily due to gradual accumulation of detrital material and hence an increase thickness of surface deposits. This may be attributed to water transportation (alluvial) or wind transportation (aeolian). A thin layer of surface deposits (soils) is amply moistened during the rainy season but will eventually be dried throughout the long rainless season. This is a habitat suitable for the growth of short-lived ephemerals that may complete their life cycle within 4-6 weeks. A deep layer of surface deposits allows for storage of some moisture in deeply seated layers reached by the deep roots of perennials. Vegetational change concomitant with gradual building of surface deposits is mainly change from chasmophytes (on rock surfaces), to ephemerals (on thin soil), to succulent plants (on shallow soil), to desert grassland, to climax scrubland.

PHYTOECOLOGICAL MAP

EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E. L. Emberger.

Scale 1 : 50 000

Contour Interval : 10 m

Figure 10

LEGEND.

A. ZONAL UNITS

P ≃ 150mn m ≃ 9,3°c. $Q_2^* \simeq 20$

Q_2^* = EMBERGER index

I. RANGELANDS UNITS

1. Coastal dunes

1.1. Active "baby" dunes near the shore. Association with *Ammophila arenaria* and *Euphorbia paralias* .... **AE**

1.2. Stabilized dunes and protected deep sand shadows. Sub-association with *Ononis vaginalis* of AE .... **OE**

2. Rocky ridges and Inland plateau

2.1. Calcareous crust

2.1.1. With intermediate category of nature of surface and moisture availability. Association with *Gymnocarpos decandrum* and *Anabasis articulata* .... **GA**

2.1.2. Least rocky sites with high moisture availability. Sub association with *Plantago albicans* of GA .... **GP**

2.1.3. Calcareous crust near the sea. Variant with *Zygophyllum album* of GP .... **ZG**

2.2. Calcareous crust with sandy deposits

2.2.1. Shallow sand. Association with *Anabasis articulata* and *Hammada scoparia* .... **AF**

2.2.2. Heavy sand deposits. Sub-association with *Plantago albicans* of AF .... **PF**

3. Depression and Sandy plain

3.1. Non-saline depression on sandy soils with low content of $CaCO_3$. Association with *Anabasis articulata* and *Echiochilon fruticosum* .... **AA**

3.2. Very low salinity. Sub-association with *Plantago albicans* of AA .... **AP**

II. CULTIVATED FIELDS

The group of species wich appear in such fields (cropping and planting) are here quite the same. They are mainly annual species correlated with sand and we cannot find great difference between the conditions saline or non-saline. Each unit on the map is described by two symbols :

- first according to the specific association or sub-association of cultivated fields
- second, in brackets, evoke the rangeland phyto-ecological association or sub-association cultivated here. This second symbol give also the color of the unit on the map.

Association with *Achillea santolina* .... **as**

Sub-association with *Chrysanthemum coronarium* of as .... **cc**

III. DEGRADED UNITS

Degraded units are here coded by the symbol .... **ZN**

The symbol of the most suitable phyto-ecological association or sub-association in acceptable rangelands conditions is added between brackets according to the environmental situation.

B. AZONAL UNITS IN SALINE DEPRESSION

1. Areas with water-table more than one meter deep and low level of salinity. Association with *Limoniastrum monopetalum* and *Asphodelus microcarpus* .... **LA**

2. Areas with water-table one meter deep and intermediate level of salinity. Association with *Salsola tetrandra* and *Suaeda fruticosa* .... **SS**

3. Areas with very shallow water table and high level of salinity. Association with *Arthrocnemum glaucum* and *Halocnemum strobilaceum* .... **AH**

C. PARTICULAR SYMBOL

This symbol is used for the sandy beach ....

Retrogressive changes are initiated as a consequence of destruction and removal of surface soils by agencies of erosion.

The assumption could be made that removal of human pressure on natural and artificial ecological systems would lead to evolution of the spontaneous vegetation. It would proceed from present plant development capabilities, subject to interactions among the pioneer and invader species available in a given area, towards a more advanced type. We could then visualize the phytodynamics, the units of which may be the "sequence of vegetation" (the most predictable vegetation type, considering present trend ; but not the "climax").

The climax community or communities in the Mediterranean coastal region of Egypt cannot be definitely determined owing to the scarcity of natural tree communities. However, there are two shrub communities that dominate this coastal strip of the desert, namely, the *Atriplicetum halimi* on developed salt marshy soils and the *Thymelaeion hirsutae* on other desert grounds. Areas cultivated with barley could have been inhabited by any of these communities had it not been for the farming operations practiced there in. Other biotic factors as extensive grazing and cutting of the plants have certainly a profound influence upon the density of these communities and their normal composition and further development.

There are however certain patches of vegetation that were found in refuge of hidden and relatively isolated and protected ends of valleys. An example is the community that inhabits Wadi Hashem, about 45 km east of Mersa Matruh and about 5 km south of the sea coast, where the following plant list was obtained from a sample area (100 m^2) with a degree of cover of 80 % (LONG 1958) :

Recorded species	(New synonym)
Capparis spinosa	(*Capparis aegyptiaca*)
Rhamnus oleoides var. *libyca*	(*Rhamnus lycioides* var. *libyca*)
Varthemia candicans	(*Jasonia candicans*)
Artemisia herba-alba	
Lycium europaeum	
Asparagus aphyllus	
Phlomis floccosa	
Atriplex halimus	

At the uppermost end of the Wadi there is a single tree of *Ceratonia siliqua* which is claimed by the local inhabitants to be wild.

Another valley called Wadi Zeitouna, about 1 km west of Wadi Hashem, shelters another patch of rich vegetation from which the following plant list was obtained :

Recorded species	(New synonym)
Rhamnus oleoides var. *libyca*	(*Rhamnus lycioides* var. *libyca*)
Pituranthos tortuosus	

Varthemia candicans	(*Jasonia candicans*)
Phlomis floccosa	
Atractylis flava	(*Atractylis carduus*)
Atriplex halimus	
Asparagus aphyllus	
Asphodelus microcarpus	
Olea europaea }	Single trees at the
Ceratonia siliqua }	top of the wadi

LONG (1955) believes that the presence of these species together with *Olea europaea* and *Ceratonia siliqua* is reminiscent of degraded maquis of the *Olea-Ceratonion* type. This group of species belongs in his view to the floristic complex of open forests of *Juniperus phoenicea*, *Pistacia atlantica* and *Olea europaea* var *oleaster*. We believe that this is quite reasonable under the light of climatic conditions prevailing in this area but that it needs further intensive studies to confirm such assumption.

From the foregoing account, it becomes evident that this area offers high vegetational potentialities. The present vegetation is undoubtedly a degraded one. The fact that soil development has actually taken place in protected places with relatively stable conditions is a definite proof of what can happen all over the area if conditions of stability are secured. LONG (1954) suggests two types of vegetation that can be promoted in vast areas in the region.

1. grassland by giving the chance to local plants to attain their natural abundance either through preservation of reseeding or both, and
2. a forest-like type of vegetation by cultivating olive and carob trees in areas with sufficiently deep soil, and particularly catchment areas. It is predicted that through re-afforestation this might become a country of high production of olives.

However, more intensive vegetational and soil studies supplied with proper mapping should be very useful achievements for the proper exploitation of the potentialities of this area.

It is difficult to determine the rate of deterioration that occured in the study area. More difficult yet is to calculate the speed of transformation between two successive steps of the evolution (deterioration and regeneration). Such studies need long periods of measurement in different ecosystems and in different situations ; however through the use of aerial photographs we can have an idea of the rate of evolution according to the land use (see section 3.2).

3.1.5. Human and socio-economic systems.

The concept of human settlements is both social and physical. A human settlement may be viewed as the concentration of population and human activities in time and space and as having two components : human groups and their habitat.

3.1.5.1. Tribal structure and population.

Before discussing the distribution and the evolution of human settlements at El Omayed, we shall analyse the tribal structure and distribution in space. As elsewhere in the coastal desert of Egypt, the population at El Omayed is organized in tribes. Every tribe is divided into sub-tribes. Land is divided between these groupings according to tradition, size of grouping and its influence, and the conflict between tribes and sub-tribes. In other words, land is divided according to a complex combination of factors which determines what may be called power relations. Every grouping or sub-tribe controls a certain area of land which may extend for many square kilometers.

One hundred years ago, land at El Omayed was divided between the sub-tribe Shtour and the sub-tribe Abou Shinaina. After that the members of the sub-tribe Ahmed began to come to El Omayed in succession, and buy land from the sub-tribe Shtour. Today, the prevailing situation from the point of view of land distribution is as shown in Fig. 11. The tribal origin and population size of these three sub-tribes in El Omayed and vicinity (total of 13,900 hectares) are indicated in Table 10.

Table 10. Tribal structure at El Omayed test-area and vicinity

Name of sub-tribe	Tribal origin	Population size (inhabitants)
Abou Shinaina	Jumaiat	700
Shtour	Jumaiat	400
Ahmed	Awlad Kharouf	300

The annual rate of growth of the population at Hammam (Ministry of reconstruction housing and reclamation, 1981), in the period between the two censuses done in 1960 and 1976, was 2.52 %. So, with the absence of data for El Omayed, we shall assume that it represents the same annual rate of growth of its population. We may add that since we have no data concerning the distribution of the population according to sex and age, and since these data about Hammam are available, we shall consider the distribution of El Omayed as similar to that of Hammam (Table 11).

Table 11. Distribution of population by class of age in El Omayed and vicinity according to the means of census of 1976 (Central Agency of General Mobilisation and Statistics 1978) for Hammam township.

Age class	Means for Hammam %	Assessment for El Omayed and vicinity (Nb of persons)
< 12 years	36.6 %	512
12 to 65 years	61.7 %	864
> 65 years	1.6 %	22

According to this table it appears that the population at the working age represents the major part (61.7 %) of the total population.

The same census of 1976 gives for the population of Hammam township the percentages of males and females of 53.4 % and 46.53 % respectively. Applying these percentages to El Omayed we will have 749 males and 651 females.

Drawing on these data, we suggest that the structure of population at El Omayed may be characterised by :

- a rapid rate of growth
- youth represents a large proportion of the population
- numbers of males and females are nearly equal.

Traditions and general consensus prevent any sub-tribe from holding land of others. Among the important features of this system is the fact that inhabitants of territories know well the limits of their own properties, though they seldom recorded in any form of registration. Legally, the tribal possession of land is not based on statuary law ; the people are no more than persons in actual physical occupancy of land, which in reality, belongs to the State. It is clear that legal ownership is different from actual physical occupancy. Legal ownership is based on the power of law and is protected by the State ; on the other hand, actual physical occupancy is just physical authority on land, and is not protected by law or the State. Within each sub-tribe, land is divided among the members according to criteria which are determined inside the sub-tribe, and which are based on power relations. It means that no outsider can purchase land or utilize it without the consent of the person in actual physical occupancy, and the owner himself is not completely free to dispose his share of tribal property ; he has to give priority to the member of his tribe at a lower price. Here we find that the traditions and the general consensus have a more important role than the State law, and we can point out the difference between legal ownership and the modes of appropriation.

3.1.5.2. Distribution of human settlements.

Human settlements represent a dynamic relationship between man and

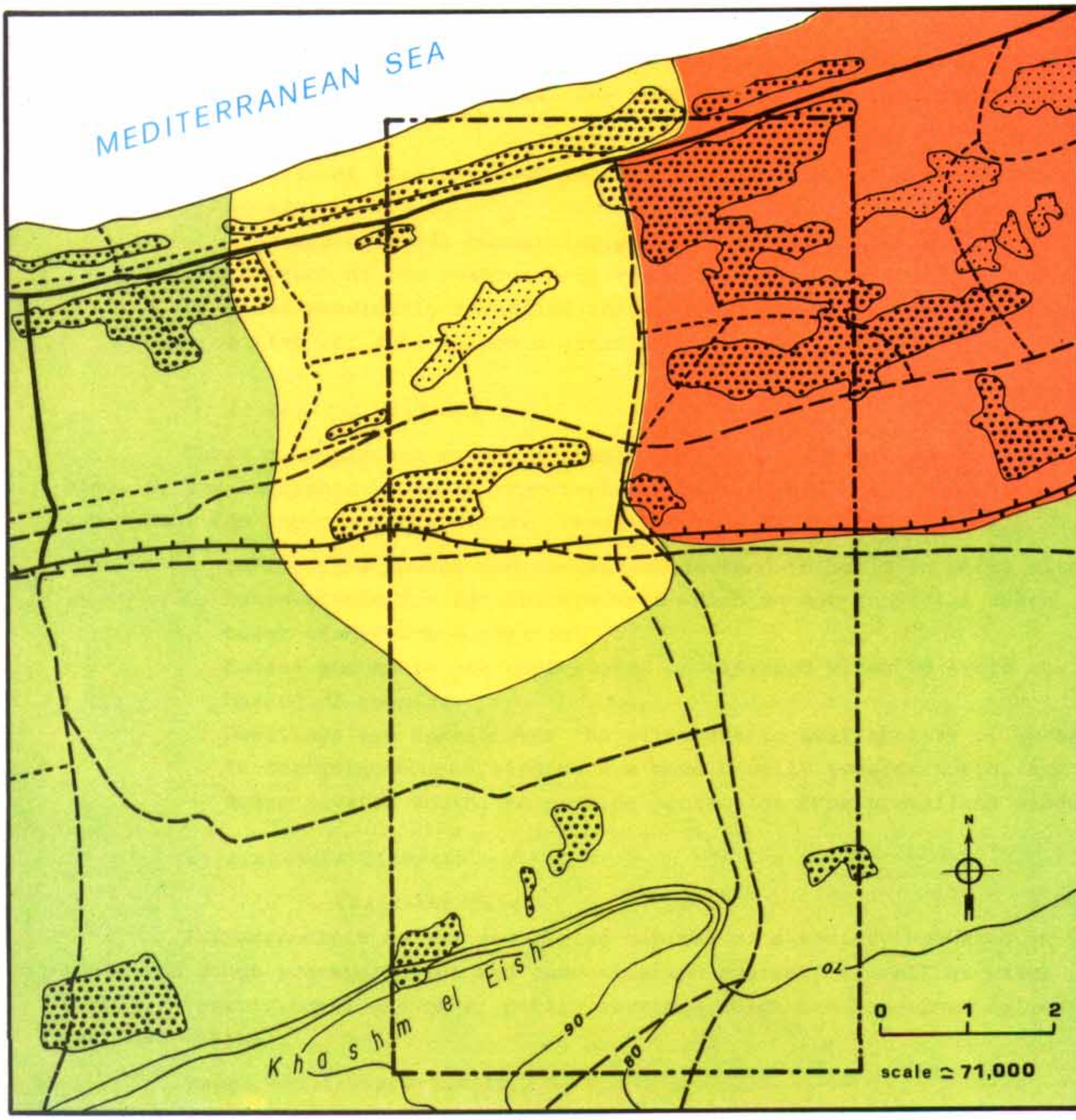


Fig.11_Land utilization according to sub-tribes distribution at El Omayed and vicinity

Sub-tribes

- Abou Shinaina
- Shtour
- Ahmed

Land utilization

- Rangelands
- Cropped fields (barley)
- Orchards (figs)

Roads and railway

- main road
- wide and good track
- narrow track
- railway

El Omayed test-area

environment. The existence and the evolution of human settlements can be dealt with in relation to several elements. Two sets of such elements may be distinguished :

Ecological elements such as climate, topographic features, soils nature ... etc .,

Economic elements concerning previously established infrastructures such as the coastal main road, railway ... etc . at El Omayed. These previously installed infrastructures often provide possibilities for some economic activities besides agriculture.

a) Ecological elements

These elements are either climatic, such as rainfall, run off and wind, or physiographic, such as topographic features, soil nature ... etc. We can detect the impact of ecological elements in the following points :

- In locating houses and tents, nomads tend to build on rocky sites not suitable for agriculture, and which do not support a dense cover of herbs and grasses.
- Houses and tents are constructed on elevated sites to avoid the hazard of runoff.
- Dwellings are spread over the sites due to availability of space.
- In designing houses, windows are made usually towards north, and doors towards south, to provide protection from prevailing winds.

b) Economics elements

. *Infrastructure*

Infrastructure is the underlying capital of a society embodied in roads and other transportation and communication systems, as well as water supply, electric power and other public services which are sometimes called overhead capital.

Roads and transportation

These form an essential element that determines the density of population. Apart from Alexandria-Matruh road, all other roads are unpaved, or are foot paths. Fig. 12 shows that the concentration of population is greatest at the coastal road and just beside the railway. Means of transportation are trains, buses and cars which have increased in number during the last few years. It may be noted that the density of human settlements decreases from north to south.

Water supply

Water is one of the most important factors affecting population density. There are 13 Roman cisterns at El Omayed which in favourable conditions collect and store rainfall. During the second world war, the British army constructed a water station and a water pipe line which passes along the railway. Another pipe line was constructed along the coastal road 6 years ago. Water is transported by carts. This transportation is done mostly by women. There are some families which have cars or tractors with tanks for transportation of water. Consumption of water varies seasonally according to the size of family and its herd.

Means of communication

There is one telephone at El Omayed station.

Schools

There is one primary school near the coast, and other two classrooms as may be seen in the Fig. 12.

. *Habitat distribution*

The general distribution of the habitats is shown in the Fig. 12 for El Omayed test-area and vicinity according to the distribution of the infra-structure. We may also mention that 44 houses belong to the Abou Shinaina sub-tribe, 39 houses to the Shtour sub-tribe and 26 houses to Ahmed sub-tribe An accurate location of the houses can be seen on the map. Another way of expressing these results is presented in Table 12, in which it is obvious that de distribution of habitats is influenced by different elements and according to rules similar to those which govern the distribution of the types of land-use.

Table 12. Distribution of habitats in El Omayed test area in 1979 according to physiographic units.

Physiographic units	Houses		Tents	
	number	density /km^2	number	density /km^2
1	0		0	
2	0		0	
3	0		0	
4	0		0	
5	0		0	
6	12	≃ 12	0	
7a	0		0	
7b	3	< 1	0	
7c	1	< 1	0	
7d	6	66	0	
8	8	30	0	
9	1	< 1	1	< 1
10	6	≃ 6	1	≃ 1
11	6	≃ 1	0	
12	6	< 1	0	
13	1	> 1	0	
14	0		0	
15	0		0	

It appears that houses are not built near the seashore probably due to the effect of wind, and also are not built inland. Some physiographic locations seem to be more favorable such as rocky ridges and the indurated

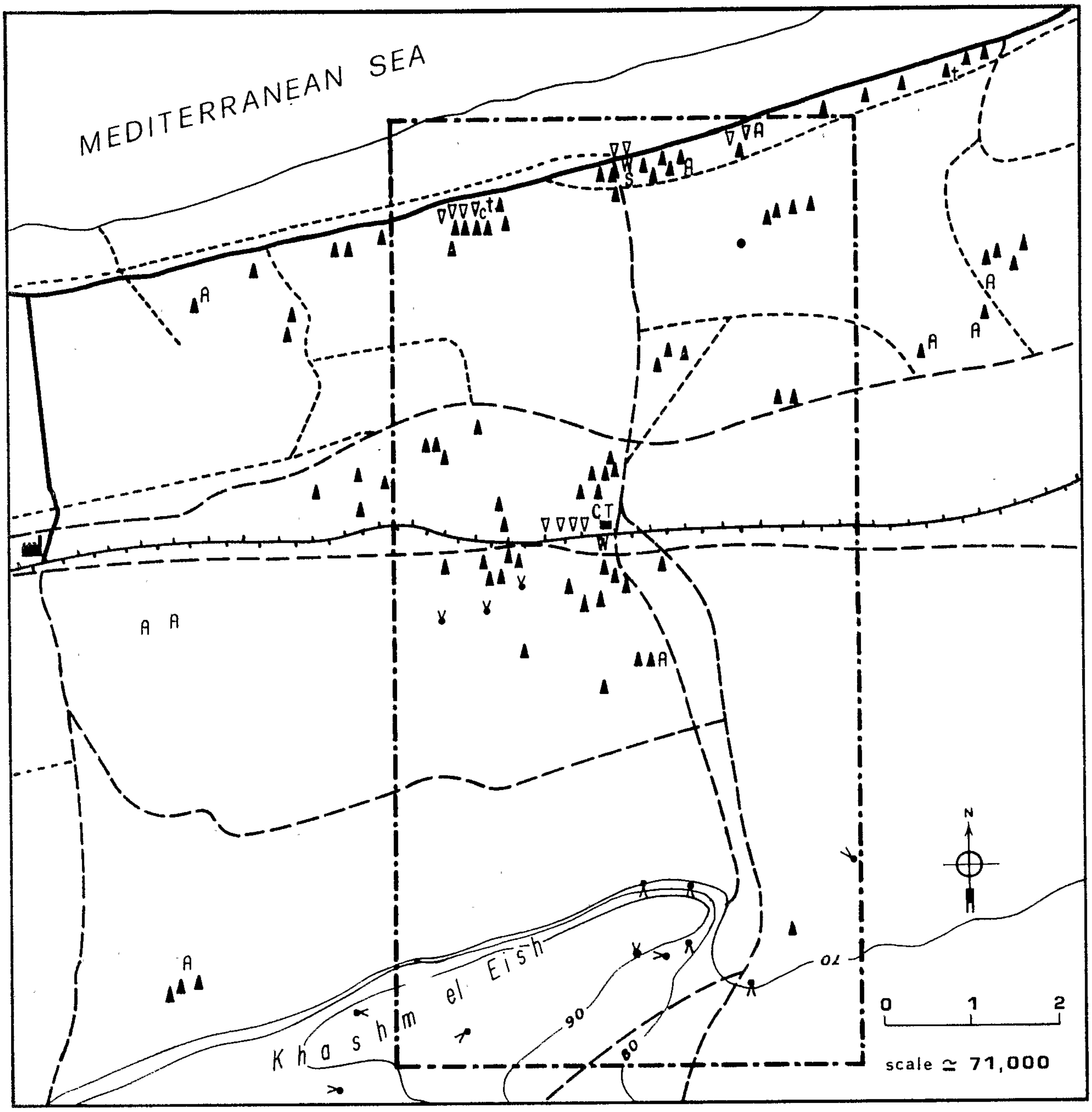


Fig.12. Distribution of human settlements and infrastructure at El Omayed and vicinity

Habitat

- ▲ House
- A Tent
- ▽ Shop

Roads and communications

- railway
- railway station
- main road
- wide and good track
- narrow track
- T Telephone

Water supply

- W Watering point along water pipe
- t Water tap along water pipe
- • Dug well (very saline)
- Cistern

Education

- S School
- C Class

Other

- Gypsum factory

El Omayed test-area

convexity (units 8, 10, 7d) where 40 % of houses are located. The southern slope of the first rocky ridge is also a favourable location due to protection against wind blowing from the sea, proximity of a large road and the presence of a school and tree plantations.

. *Productive activities*

Man's existence is associated with the possibilities of productive activities, and accordingly the existence and evolution of human settlements are functions of such activities. Natural resources are not determined once and forever, but as function of man's knowledge about nature. The level of knowledge is reflected in the development of productive forces which enable man to modify nature for satisfying his needs. Pastoralism has been the main activity at El Omayed for hundreds of years. This is an occupation which is based on the movement of inhabitants mainly for seeking pastures. Local inhabitants therefore used to live in tents that can be easly moved. The tent used in winter is made of wool and that used in summer is made of jute. There was also moving agriculture of barley. Seeds were sown, in one place left to grow, and at the end of the season, inhabitants come back to harvest it. Besides there was little cultivation of fig on sand dunes. In the transect of El Omayed (50 km^2) there were only 4 houses and 55 tents in 1954 with a density of < 0.1 per km^2.

The government policy to sedentarize nomads involved the provision of feed and food supplements as well as transplants and cuttings for cultivation of fruit trees. The government also offered assistance for building houses and covered costs of cleaning Roman cisterns.

The expansion of fig cultivation, and agriculture, then played an important role as on economic activity. We can detect a parallel relationship between the expansion of fig cultivation and the sedentarization of the local population. Also the increasing of human settlements was accompanied by the launching of many projects such as : construction of touristic villages, quarries of gypsum factory, and the widening of Alex-Matruh road. These projects created job opportunities for El Omayed inhabitants. Trade evolved a new economic activity due to production increase and exchange, the increase of traffic on the main road,the presence of outsiders who work for projects, and the increase of income.

Local inhabitants started to settle down to practice these permanent activities. As a result of sedentarization, houses were constructed. Its number became 50 houses in 1979 in El Omayed transect, and gradually replaced tents (Table 13) . Tents are still constructed in some seasons in response to ecological considerations such as summer heat, or in response to social needs such as marriage festivities.

Table 13. Evolution of the number of houses and tents in El Omayed test-area (5000 hectares) from 1954 to 1979.

Year	Houses		Tents	
	Number	density /km^2	Number	density /km^2
1954	4	< 0.1	55	1
1962	12	< 1	30	< 1
1979	50	1	2	0.04

3.1.5.3. Systems of production.

We mean by a system of production all means involved in production (e.g. land, vegetation, soil, water, tenure, tools, available goods and labour force) taken together. These factors permit both production and reproduction and enable man to achieve to one or more different objectives. Table 14 shows the land tenure structure for 25 households surveyed in El Omayed and vicinity.

Table 14. Land tenure for 25 households at El Omayed and vicinity in 1982.

Class	Nb. of owners	total area (T.A)	average T.A.	utilised area (U.A)	average U.A
< 50 feddans	6	236	39	125	21
50-100 feddans	7	531	76	173	25
100-200 feddans	5	860	172	270	54
More than 200 feddans	8	2965	370	1780	222

The area under exploitation in each category varies in function of soil nature (its physiographic conditions), and the financial possibilities of every household.

The system of production at El Omayed may be viewed as consisting of certain sub-systems each including sub-sub-systems. As mentioned before the major part of El Omayed area is rangelands (78,4 % of the total area) which seems to be the most closely linked activity with the way of life of the local tribes.

a) Sub-system of animal production.

The camel production has radically decreased in contrast to the sheep and goat production which has increased for El Omayed and vicinity from 10,000 heads in 1973 to 17,845 heads in 1978 (Statistics of Depart. of Agriculture-Hammam 1978) due to the increase in market demand by Arab countries and to the reduction of transport by animal.

Herd size depends on the amount and the distribution of annual rainfall in time and space. Lambing and kidding usually take place between August and October after a five-months gestation period. The youngs remain with their mothers for four of five months before weaning, at which point the males are sold at Hammam, and the females are kept in order to increase the breeding stock. Under optimal conditions, sheep and goats could reproduce twice yearly. However, under local conditions of scarce pastures, fodder and recent years of drought, the field study showed that only 14 % of the goats and 27 % of the sheep did reproduce twice a year (1981). The ratio of sheep to goats is 3:1 in El Omayed and observation of 25 herds indicates that they are usually mixed, including both sheep and goats in the same proportion as the overall population. The ratio of males to females is about 1:40 for both sheep and goats. Once females exceed the age of reproduction, they are sold and this generally occurs after six years. If a female fails to reproduce or the owner is financially stressed, younger females may be sold.

During the period from January to April, herds are grazing natural pasture (grasses, herbs and shrubs) mainly in the area located inland of Khashm El Eish. During this period and even throughout the whole year, the main problem for herdmen is to provide water for the grazing animals. Most cisterns, the only watering points behind Khashm El Eish, are unusable as real sources of drinking water. Even for the inhabitants, the water points are only along the water lines (near El Omayed station and near the coastal main road).

After this period herds, chiefly older animals (two years old or more) are usually taken to Beheira and Tahrir region in the Nile delta to graze bersim and stubble after harvesting. Suitable stubble comes from the following crops : coton, wheat, water melon and corn. The costs in 1981 are estimated at 150 piasters/head/month. An alternative to grazing on stubble residues in the fields is providing vegetable residue which is a waste product from the onion and garlic processing plant near Alexandria. Animals graze there at least from June to October and sometimes more.

Barley used to be a major source of animal feed during summer months, but in the last few years the barley crops have failed due to drought. In the early 1960's, the government started to provide nomads with subsidised feed to reduce the pressure on rangelands, and to sedentarize the population. The quantity of feed provided at the beginning of the program was 20 kg/head/month. It decreased gradually, and now the amount provided is 3 kg/head/month at the cost of 0.04 Egyptian Pounds (E.P.)/kg. In addition to the subsidised feed there is unsubsidised fodder available at the cost of 0.10 E.P./kg. Animals eat fodder in summer and fall, and even in winter in dry years.

Herdsmen are paid 35 Egyptian Pounds per month and are fed by the owner of the animals. The income of this type of production system is achieved by sale or auto-consumption of meat, milk and wool. Most of the male off-spring is sold at the age of five months after weaning. At this age, lambs are sold for 50 E.P., and goats are sold for about 20 E.P. Most of the females are kept for breeding as long as they are able to reproduce.

Sheep and goats are milked twice a day. Goats yield about 1 kg of milk per day in the five months after delivery, whereas sheep yield only about 0.5 kg per day and only during the first month after delivery. Milk is used completely by the household (auto-consumption). Neither milk nor its products (cheese, butter) are sold in the market.

Only sheep give wool. Every head produces 2-3 kg of wool/year. Shearing is done by specialists from other regions during March and April. Some of the wool is used by the household. Women make carpets from sheep's wool. Surplus wool is sold unprocessed at the market for 0.45 E.P./kg.

Production and supply of sheep and goats are a function of price level (in addition to rainfall and fodder), other things being equal. Price increase results from the demand increase from the inside as well as the outside. The price of a lamb aged 5 months increased from 5 E.P. in 1967 to 50 E.P. in 1981. The behaviour of farmers in such situation is to introduce the changes in the other sub-systems (i.e. mainly of plant production).

b) *Sub-system of cultivated plant production.*

Agriculture at Omayed is very ancient, but it was less important in the past than pastoralism. A great change has taken place during the past two decades. To study this sub-system, we shall examine its sub-sub-systems.

Crops

Barley is the dominant crop due to its short life cycle which makes possible its cultivation during the period between December and April when the water balance is more favourable even in sandy soil and in saline depressions (before the rising of water by capillary movement).

Land under barley cultivation is exploited either directly by its owner, on indirectly under sharecropping when the land owner gets only one quarter of production and the sharecropper gets three quarters and provides the labour and other costs.

Barley is used to make bread (final consumption) as well as to feed animals (productive consumption). The rest is for the market. In the early 1960's, the government provided nomads with subsidised fodder for animals, and wheat flour at a low price. By time, wheat flour replaced barley for human consumption. This substitution is economically rational given the present price structure. The price of barley has gradually increased, it is now sold for 0.10-0.12 E.P. per kg, apart from the costs of milling. Meanwhile, wheat flour which is heavily subsidised, is sold for 0.07 E.P. per kg. Fodder also replaced barley in animal feeding, since it is also subsidised and therefore cheaper. In addition to these economic reasons, the zone has recently suffered from drought, so there was no return on the investment in barley cultivation. Besides, the yield of barley became less paying relative to yield of other crops such as fig which can tolerate periods of drought.

In addition to barley, other crops are also cultivated such as water melon and seed melon, but they are relatively rare.

Tree plantation

Fig plantation is an ancient practice on the coastal sand dunes, where the water table is about 2 meters from the surface, and more generally is cultivated between the first rocky ridge and the shore. The distance between trunks is 5-8 meters and the plantation is of a specific variety "Sultani" of low trees. Under the conditions of coastal dunes, these trees are protected against damaging winds blowing from the sea by wind breaks, like for instance raws of dead shoots of *Ammophila arenaria*. In other situations, figs are generally cultivated in areas which receive runoff water with greater distances between trees (8-14 meters) due to the scarcity of water resources (deeper water table).

Decreasing the density of plantation permits its extension inland till the northern slope of Khashm El Eish where small dykes of sand are constructed to collect runoff water for trees. When rainfall is scarce, tractors and tanks are used to irrigate small trees in summer.

There are two patterns of exploitation :

- direct exploitation by the land owner
- sharecropping : the land owner gives his land to another person to cultivate it. The later pays all the costs of cultivation. When plants are mature, after five years, he gives one half of trees to the land owner, and keeps the other half and the land for himself.

Tree plantation has a very recent, but very fast, evolution based on some economic reasons :

- speculation in the sale of coastal land has provided the capital necessary for the expansion of fig cultivation ;
- the sedentarization of the population and the need of a stable source of income created a motive to increase this crop ;
- price increases from 0.05 E.P. to 0.50 E.P. per kg in the last 14 years, which was accompanied by market expansion and development of means of transportation.

The law N°100 of 1964 stated that all land, except for land cultivated with trees, or land with permanent dwellings, belong to the State. This encouraged the local inhabitants to cultivate trees in order to claim land ownership.

The effects of such an economic and sociological situation are very clear on the evolution of the number of fig trees as shown in Table 15.

Table 15. Trend of evolution of the number of fig trees from 1977 to 1982 (inquiries on 25 households in El Omayed area and vicinity).

Year	1977	1978	1979	1980	1981	1982
Nb. of fig trees	38500	42250	58400	67400	73000	99000

Other trees are also present : natural as palm-trees or introduced as olive trees. They are not numerous probably due to different ecological reasons. The palm tree is well adapted to salinity and need high level of soil moisture. Such conditions are found in the study area only near the shore where the atmospheric humidity does not permit production of really tastefully dates. The olive tree which may grow tall is sensitive to the wind. Thus the nearest plantation to the shore in the study area is approximately 4 km inland, and still needs a heavy network of windbreaks. High atmospheric moisture also provoke some diseases, and the maintenance of olive trees needs a good technical level.

c) *Other sub-systems of production*

Rainfall is one of the most important elements in the dynamics of the last two sub-systems. It affects production and yield. The two sub-systems are characterized by high degree of uncertainty. This fact forced El Omayed inhabitants to vary their activities, and exploit other sources of income. Excluding pastoralism, the non-agricultural activities are :

Trade : Demographic growth, extended activities, existence of army, increase in rate of transportation and existence of outsiders led to an expansion of trade. Also, these factors led to an increase in shop numbers along the coastal road and near the railway station.

Job opportunities : The recent construction of quarries and the factory of gypsum 10 years ago, the widening of Alexandria-Matrouh road, and the construction of touristic villages have created many job opportunities.

Hunting : Hunting of some kinds of birds takes place during September and October by means of setting traps in the trees as well as at the seashore.

Transport : An increasing number of inhabitants own vehicles. These vehicles are used to transport people, crops and stones.

The production system and its sub-systems at El Omayed represent in its function and its evolution a certain type of resources allocation. The study showed that this system was based on a certain structure in which pastoralism was relatively the most important.

After the sedentarization of nomads, and the insertion of the region, including El Omayed, in the market economy by launching many projects, a resources reallocation has taken place in function of yield and cost. Pastoralism was no longer the main source of income, other activities gained importance, specially agriculture. The variation of activities comes from the fact that both agriculture and pastoralism are characterized by uncertainty, since rainfall plays an important role in the dynamics although uncertainty in agriculture is less than that in pastoralism. Our field study showed that every household is based on a group of activities, and that the role of agriculture is increasing.

From this study we can point out the following results :

- it is not possible to understand the evolution of production systems without considering ecological conditions and without considering the underlying economic and social conditions. It becomes obvious that these two terms have an influence on the magnitude and value of resources ;

- the resources reallocation caused a modification in the components and relations of economic structure on which the system of production is based This modification is from a structure based on pastoralism to a structure based on a group of economic activities in which agriculture has an increasing role. In other words, a great change has taken place in the economic structure which led to the evolution of the system of production. This change in the structure is based on the mobilisation of human and natural resources. At the last analysis, the changes and transformations in the system of production represent an acceleration in the rythm of transformation from the subsistence economy to the market economy.

3.2. EVOLUTION OF ECOLOGICAL CONDITIONS DUE TO CHANGES IN HUMAN PRESSURE.

The changes in the conditions of utilization of resources lead to modifications in the components and organisation of economic structure on which the system of production is based. These modifications are from a structure based on pastoralism to a structure based on a multiple-use strategy or on a group of economic activities in which agriculture has an increasing role. In other words, a great change has taken place in the economic structure which lead to the evolution of the system of production. Such evolution may be clearly visualized in studying the evolution of land-use types from 1954 to 1979 through the interpretation of aerial photographs in relation to the physiographic units as they have been described and mapped in Fig. 3. According to the various requirements for labour force for each main type of land use, we think that the evolution of the systems of production could be analysed and understood through the evolution of human settlements (types and location) as shown in Table 12 ; data in this table are derived from observations of aerial photographs, and interpretation of population census related to demography, labour force ... etc. The first impression on examining the data on human settlements in Table 13 may lead to the assumption that there is a signifiant decrease in pastoralism as indicated by the nearly absolute abandonment of tents as a traditional type of human habitat. This is a false assumption, because rangeland of about the same area as before is still overused.

Table 16 includes data on the evolution of land use according to the physiographic units which may provide good information about such evolution for the past and for the future. Looking only at the last collumn ("TOTAL") of this table we may draw the following conclusions :

Table 16. Evolution of land-use (1954-1962-1979) according to the physiographic units in test area (5000 ha).

Physiographic units		1	2	3	4	5	6	7a	7b	7c	7c	8	9	10	11	12	13	14	15	TOTAL
Area of the units (in hectares)		17	126	27	34	62	102	60	844	219	9	27	316	98	504	927	934	276	408	4990
1954	RANGELANDS		92	13.5	27.8	62	94.2	60	740	141	9	27	285	98	482	927	903	276	387	4264.5
	CROPPING LANDS	0	0	135	6.2	0	4.7	0	93	45	0	0	28	0	8	0	25	0	21	244.4
	ORCHARDS	0	34	0	0	0	0.1	0	11	33	0	0	3	0	14	0	6	0	0	104.1
1962	RANGELANDS		92	0	27.8	62	47.3	60	740	70	9	27	189	98	457	922	857	276	408	4344.1
	CROPPING LANDS	0	0	12.5	0	0	26.6	0	70	91	0	0	68	0	30	5	53	0	0	356.1
	ORCHARDS	0	34	14.5	6.2	0	28.1	0	34	58	0	0	59	0	7	0	34	0	0	274.8
1979	RANGELANDS		92	0	16.5	62	62.9	60	680	0	9	27	126	98	455	922	874	276	408	4168.4
	CROPPING LANDS	0	0	12.5	2	0	11	0	120	0	0	0	70	0	27	0	31	0	0	273.5
	ORCHARDS	0	34	14.5	15.5	2	28.1	0	44	219	0	0	120	0	22	5	29	0	0	531.1

- the surface of rangelands seems to be constant, and after a notable decrease between 1954 and 1962, the reduction in area between 1962 to 1979 appears to be trivial. We can also note that a comparison between Tables 6 and 14 indicates a fast evolution since 1979 represented by the sudden increase in orchards (figs) cultivation, probably due to economic considerations ;

- the cropping area increased by 1.54 fokd between 1954 and 1962 and them decreased after that ;

- orchards (tree plantations) increased by 2.97 fold from 1954 to 1962 and by 1.42 fold till 1979.

A more accurate examination of this table is required for the understanding of the correlation between land-use and physiographic conditions. Table 17 gives a synthetic view which may be more useful for this comprehensive interpretation.

Table 17. Presence of crops (*) and/or orchards (.) at various dates (1954, 1962, 1979) considering various physiographic units.

	Physiographic units																	
	1	2	3	4	5	6	7a	7b	7c	7d	8	9	10	11	12	13	14	15
1954		.	*	*		*.		*.	*.			*.		*.		*.		*
1962		.	*.	*.		*.		*.	*.			*.		*.	*	*.		
1979		.	*.	*.		*.		*.	.			*.		*.	.	*.		

According to this more synthetic presentation we may mention the following changes :

- one unit (2) have been planted since an earlier time before 1954 ;
- six units (6, 7b, 7c, 9, 11, 13) have been cropped and planted since an earlier time before 1954 ;
- one unit (3) has been cropped since an earlier time before 1954 but orchards appeared only on aerial photographs of 1962 ;
- one unit (15) was cropped in 1954 but not in 1962 and 1979, and without any tree plantation ;
- one unit (12) was cropped in 1962 and planted in 1979 ;
- seven units (1, 5, 7a, 7d, 8, 10, 14) were without cropping and tree plantation in the given dates of observation.

In such cases where it is possible to use data extracted from aerial photographs of different dates, one may be able to follow the behaviour not only of spatial units but also of specific well located points. In this wav we can detect another case, not so rare, of locations which where regularly cropped since before 1954 but without any tree plantation.

The increase in area of crop farming and tree plantation is certainly linked with the ecological possibilities of every physiographic unit, and with the requirements of the population in this area. It seems that the inhabitants who are changing their living conditions from pastoralism into agricultural practices as cropping and planting trees must have done their own "experimentation" or acquired of knowledge in such "new lands". Accordingly, we may extend the following remarks :

- all units (excluding rocky ones) have been once cropped with or without failure ;
- in situations where crops gave acceptable yields, other practices (i.e fig plantation) were sometimes tested and if relevant often extended. This point of view, introduced from Table 17, supports the fact which corresponds to the recent but fast trend of fig plantation already described. As mentioned in section 3.1.5., economic and sociological advantages are highest for fig income than for barley income which is progressively abandoned or only used for the testing of ecological possibilities of different parts of the area ;
- some locations may be suitable for cropping which for instance due to the level of the water table may be inadequate for tree plantation ;
- under some conditions when crop farming has been unsuccessfull, this practice is also abandoned and not followed by plantation.

Some economic or sociological changes may obviously modify such concluding remarks, or they may be emphasized with new tendancies for cropping as it is the case with the unit 15 in 1981.

This evolution described for the past few decades, influences the evolution during the next decades. So we may anticipate that the increase of human pressure according to the socio-economic conditions implies the continuation of degradation of some biotic (plant, vegetation ...) and abiotic resources. That is why it is so important to suggest that the understanding of the recent trend of change in land use pattern is necessary for visualizing the sensitivity of ecosystems to all social practices and the related risks.

3.3. SENSITIVITY AND RISK ASSESSMENT.

3.3.1. Analysis and mapping of "sensitivity to degradation".

It is well known that environmental deterioration may be anticipated in terms of current processes : impoverishment of the natural plant cover, increase of aeolian deposits, and alteration of soil surface by deflation and water erosion on foothills and glacis, etc... All these processes are going on in El-Omayed test-area. It is also obvious that these processes are not exhibited everywhere with the same intensity ; and it appears, in fact, that different types of ecosystem are not equally sensitive or susceptible to the factors of environmental deterioration. Of the main factors of such deterioration in the test-area, we may mention the following :

- overgrazing and extensive wood cutting (eradication of woody species) for fuel consumption ;
- the spreading of cultivation to previously uncultivated areas, such as rangelands ; frequent ploughing every year for cropping and several times every year (or as often as required) to get rid of weeds in orchards ;
- misuse of land around human settlements (such as houses, tents, stabling of livestock).

The study of the present situation provides a base for an analysis of the sensitivity of the environment of rural areas as shown in Table 18. It becomes possible to define at first the criterion of vulnerability. This criterion demonstrates the fact that identical conditions of land use, by man and livestock, do not produce the same effects in a given area. It is conceivable that various types of ecosystem (various types of natural plant cover and of soil, topographic location, etc ...) do not offer an equal resistance to the factors of environmental deterioration. Therefore, it is possible to classify various types of natural plant cover and soil conditions according to their vulnerability to such factors. The degree of vulnerability depends mainly on the method and magnitude of exploitation of resources ; but it can also be related to the following features :

- natural vegetation : physiognomy (dominant plant forms), plant cover, capacity of regeneration, etc. ;

- soils : topographic position, soil depth, soil structure, etc.

A ranking system, as that shown in Table 18, may be proposed for different categories of vulnerability (of "natural plant cover" and of "soils" for "grazing", "ploughing" and "human settlement"), considering the five levels of intensity for the eighteen units of the physiographic map. The combination of the degree of different categories of vulnerability enables us to propose the level of potential sensitivity.

Table 18. Analysis of the sensitivity (potential and present) of the various natural environments (El-Omayed test-area).

Code of units in physio-graphic map	VULNERABILITY					ATTRACTIVITY			SENSITIVITY	
	of natural plant cover for		of soils for			for				
	grazing *	ploughing **	grazing	ploughing	human settlement	grazing	ploughing	human settlement	POTENTIAL	PRESENT
1	NA	KA	NA	NA	NA		NA		NA	NA
2	VH	VH	H	VH	VH	1	o	VH	VH	1--VH
3	NA	NA	NA	M	1	NA	VH	o	M	1
4	H	VH	M	H	M	H	H	M	H	M
5	M	NA	H	NA	1	VH	NA	VH	M	1--M
6	H	VH	M	H	M	H	VH	VH	H	H
7a	o	NA	NA	NA	NA	1	o	NH	o	o
7b	M	M	H	H	MA	M	H	o	H	M--H
7c	NA	NA	NA	VH	NA	NA	VH	o	VH	VH
7d	1	NA	1	NA	1	H	o	H	M	1
8	1	NA	1	NA	M	1	NA	VH	M	1--M
9	H	VH	H	H	M	VH	VH	1	VH	H
10	1	NA	1	NA	M	1	NA	VH	M	1--M
11	H	VH	H	H	M	VH	VH	1	VH	H
12	H	VH	H	H	1--M	VH	1	1	H	M
13	VH	VH	H	H	M	H	VH	1	VH	H
14	H	NA	1	NA	1	VH	NA	o	1	1
15	H	VH	M	H	1	VH	M	1	H	M

* grazing includes also wood gathering for fuel.

** ploughing for cropping or planting and soil surface maintenance in orchards. However on the coastal sand dunes (unit 2) fig plantations do not require any for their maintenance ; planting could be done only by digging hole in some cases, and some planting (such as Cactus = *Opunta ficus indica*) does not require soil surface maintenance by ploughing.

Symbols : NA = not applicable M = medium o = negligible
H = high 1 = low VH = very high.

The study of the evolution of land-use according to the different units of the physiographic map has demonstrated that, in fact, there are great differences in the spatial distribution of the human practices and pressure. Man probably recognizes empirically that various areas of his environment show different levels of biological productivity, or he may be aware of the dramatic consequences of some kinds of practices on certain areas. Some parts of a territory are more or less attractive for various activities, and lead to differences in the intensity of exploitation. The level of attractivity can be considered as linked to several features such as :

. type of land tenure and type of system of production ;
. vicinity of watering points, roads and human settlements ;
. the possibility of mechanizing agricultural practices (such as

ploughing , etc.).

These two concepts, "*potential sensitivity*" and "*attractivity*" may be combined in order to provide an assessment of the "*present sensitivity*" taking into accoung the environmental risks of the current practices. As the other concepts presented here, the present sensitivity is proposed according to a hierarchy of five levels or degrees. A degree of present sensitivity for a given area is not the result of an arithmetic computation of the various degrees of potential sensitivity and attractivity of this unit, but is indicating the comprehensive sensitivity taking into consideration all aspects described in details. The results of such analysis can also be expressed, as in Fig. 13, in a synoptic map of the degrees of sensitivity (potential and present to environmental deterioration in rural areas). It is also possible to add on such map other symbols indicating, for instance, the more dominant or the detailed factors leading to deterioration (Fig. 13). Estimation of the present state of potential and actual present sensitivity is shown in Table 19.

Table 19. Percentages of various degrees of sensitivity (potential and actual) in the study area.

Degree of sensitivity	Symbol on the map	Sensitivity (% of the area)	
		potential	present
very high	VH	42	6.9
high	H	46.3	72.5
medium	M	4.5	12.6
low	L	5.5	6.2
negligible	0	0.3	0.3

It appears clearly that, even under conditions of the present practices and the present level of human pressure, about 80 % of the study area is at least highly sensitive, and that environmental deterioration probably is progressively generalized. Therefore, it is urgent to decide on a change in the trend of the present land-use and systems of production.

3.3.2. Current environmental deterioration processes.

It seems easy to follow the sequence of the process of degradation. Thus, if for any reason, the natural plant cover, which provides an obstacle to run-off and physical resistance to the wind, is reduced (by overgrazing and uprooting) or destroyed (by ploughing), the surface layer of the soil or the superficial sandy accumulation through truncation or deflation, rapidly regresses under the effect of water erosion or wind deflation. Such removal continues until the result is that there will be, on one side, a compact surface layer often with stones, and on the other side deposits of removed particles in flood areas, and also in case of sand soil, more or less heavy and less stabilized accumulations in particular locations. In other locations, the misuse of water resources for irrigation (too high water salinity, absence of drainage system), can introduce, particularly with fine textured soils, an increase of salinization, often associated with water-logging. We will briefly describe here the processes which can be detected in the test-area of El-Omayed.

a) Impoverishment of the natural plant cover.

This is the first step of environmental deterioration. In El-Omayed the protected site shows clearly the effect of overgrazing on natural vegetation by comparison with the free grazing area. The effect is mainly the decreasing of palatable species. In fact, this is sometimes accompanied by the increasing in cover of some unpalatable or less palatable plants, such as *Thymelaea hirsuta* and *Asphodelus microcarpus*. The natural vegetation, already destroyed in ploughed fileds, is decreasing in the units where the attractivity for grazing is considered "high" or "very high" (Table 18).

b) Aeolian dune formation.

The end products of wind deflation is the accumulation of soil in particular spots. Such sand accumulations may be progressively stabilized and colonised by adapted plant species, or may remain mobile. In El-Omayed test-area, we can define several types of aeolian formations, as hummocks (in saline depression) barkhans or even sand hills (in the North-West of the study area).

c) Ablation of soils by deflation and water erosion.

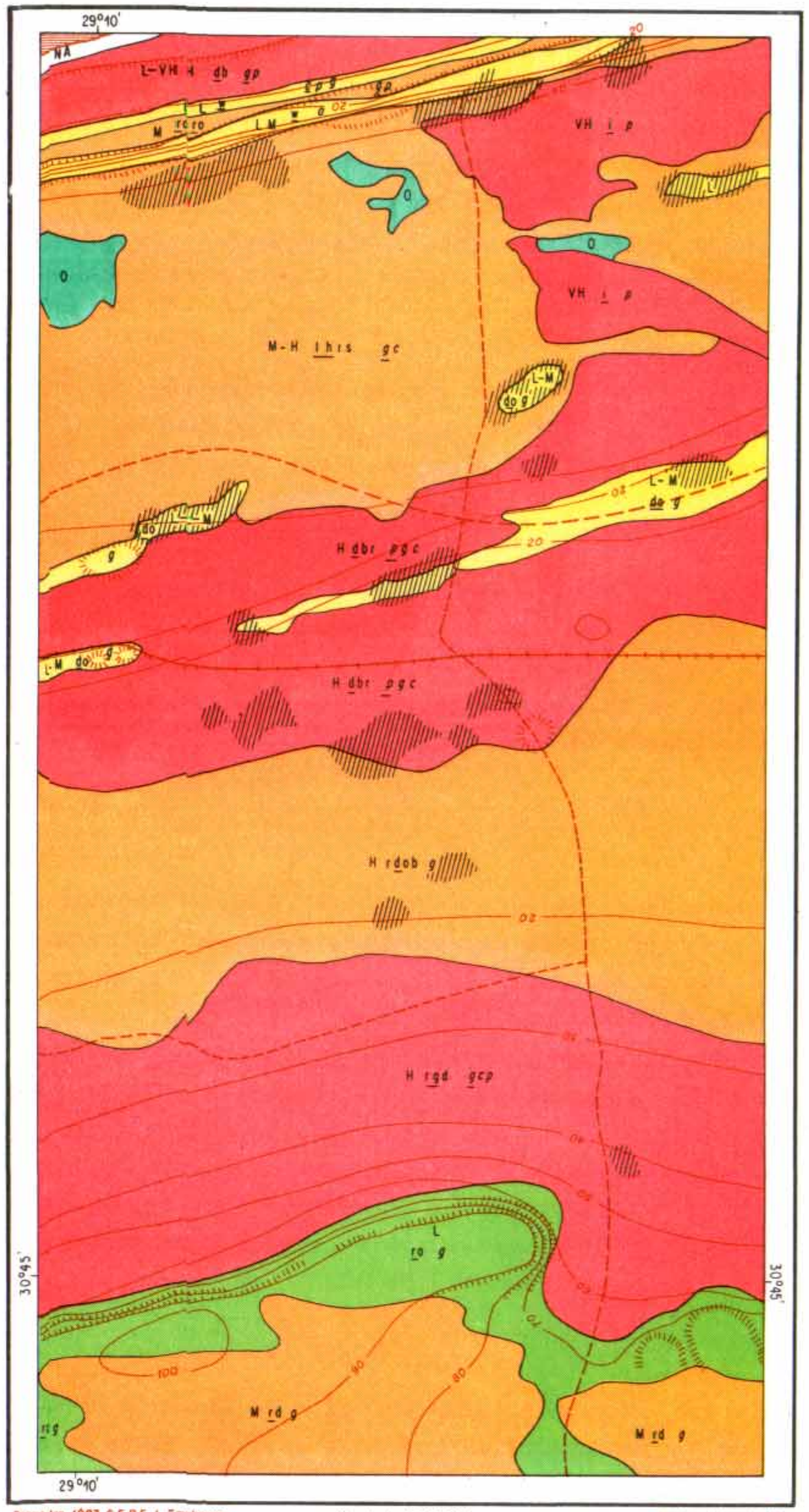
Ablation of all or part of surface soil layer leads to the reduction of the effective water supply and to the increase in runoff by truncation of all or part of the profile. Such ablation is the result of water erosion mainly in geomorphological positions of footslopes with loamy texture (sheet erosion or gully erosion), or of deflation in sandy locations. The extreme result of such process is an extension of denudation of bedrock, calcareous crust and slab or other indurated layers. The first step of this truncation is characterized by the fact that when the natural plant cover is reduced, the rainbeat seal is very quickly formed in all locations with loamy soils (even in moderate proportion). This phenomenon is also called "glazing" and is frequent in El-Omayed on loamy slopes.

d) Salinization and water-logging.

The topographic location of the physiographic unit n° 7b (Fig. 3) indicates that its soils are regularly affected by water-logging during the rainy season. There is also a relationship between ground-water, salinity and soils salinization. The importation of irrigation in any part of the test-area has certainly introduced an increase of the effect of water-logging and an extension of salinization.

SENSITIVITY MAP (present and potential)

EL OMAYED TEST - AREA



Drawn Jan. 1983 C.E.P.E.-L.Emsberger.

Scale 1: 50 000

Contour interval : 10 m

Figure 13

LEGEND

DEGREE OF SUSCEPTIBILITY OR OF SENSITIVITY

Present sensitivity given by letters and potential sensitivity in colour are expressed as shown in two last columns of table n° 18, according to the following codes :

Degree	Present sensitivity	Potential sensitivity
negligeable	O	
low	L	
medium	M	
high	H	
very high	VH	
not applicable	NA	NA

In some cases we indicate the present sensitivity with two degrees (for instance L – VH) which indicate the trend in units where even slight modification of attractivity can involve high modification of present sensitivity.

FACTORS AFFECTING LAND DEGRADATION

The dominant processes are shown with underlined small letters

- . Regression of the natural plant cover — r r
- . Aeolian sand formations
  - . hummocks — h h
  - . more or less stabilized microdunes — b b
  - . sand hills — i i
- . Deflation — d d
- . Water erosion
  - . in sheet — w w
  - . with gullies — g g
- . Waterlogging — l l
- . Tendancy to salinization — s s
- . Enlargment, of areas of outcrops or indurated horizon, by erosion — o o

HUMAN AND ANIMAL PRESSURE

- . Sedentary human concentration
- . Cropping — c c
- . Planting — p p
- . Grazing and eradication of woody species — g g

3.3.3. Deterioration factors.

The basic features of ecosystems have already been given throughout all previous sections of this part. Climate, hydrology, soils and vegetation can be analyzed as degradation promoting factors. It is conceivable that the deterioration of some physical components of the environment may lead to considerable and quick changes in the biotic components. It has been demonstrated that no significant climatic changes has taken place in Northern Africa since the beginning of the regular registration of meteorological data (end of the nineteenth century). Although the environmental deterioration is accentuated by the great variability of rainfall, the main causes of this deterioration in the study area are related to the following human activities:

a) *Sedentarization and the application of new technologies.*

The increase of sedentarization, and the introduction of new technologies for planting and cropping, have had an obvious increasing effect of human pressure on the natural environment during the last few decades.

b) *The increasing application of mechanized agriculture.*

The evolution of land use from 1954 to 1979 (Table 16) indicates an increase in cultivated area at El-Omayed of 456.1 ha. (i.e. 9.1 % of the area) due to the extension of cropping and tree plantation. Fig trees and barley are cultivated with variable success depending on annual rainfall, but the consequence is always a decrease in the area of rangelands, and an increase of grazing pressure on their vegetation.

c) *Overgrazing.*

The rangelands used by sheep and goats are destroyed progressively due to the expansion of cropping and planting areas. The main modification in the livestock systems is not a reduction of the total number as may seem to be the logical result, but only a change in the structure of herd. Obviously overgrazing leads to the reduction in palatable plant cover (number of species and above ground phytomass). There is also a significant change in the physiognomy of vegetation. It becomes progressively dominated by less palatable species and often an almost complete disappearance of annual species. Modification of the vegetation layering, reduction of plant cover, regular trampling (along the ways, around watering points and sedentarization places), promote the progress of the deterioration process.

d) *Harvesting of woody plant species.*

Rangelands already with low pasture production are also suffering the eradication of woody species used for various domestic purposes. With sedentarization the harvesting of fuel wood becomes more intensive and the effect becomes more visible around houses and tents.

With the disappearance of large shrubs, inhabitants begin to gather smaller and smaller shrubs but in greater numbers to satisfy their needs ;

the selection of shrubs also depends on the fire efficiency that they recognize for each species.

Symbols are added on the map of sensitivity , which represent various aspects of human and animal pressure on rangelands and ploughed areas. The effects of degradation or desertification have been dealt with by many studies (e.g. FLORET *et al.* 1973 ; TRABAUD 1973 ; GODRON 1978...). Here we may mention the main effects of the above-mentionned misuses on the landscape of El-Omayed test-area :

- development of a peculiar flora,as a result of overgrazing (decrease of palatable species) ;
- modification of the physiognomy of vegetation dominated by less palatable species ;
- modification of soil profiles due to various processes of water and wind erosion (ablation, deflation, accumulation). These three phenomena are interrelated together, and modification of one may involve modification of the other.

It should be mentioned that there is a great difference between the two notions of environmental deterioration and desertification. The term environmental deterioration as used in this chapter is a general notion that applies to all "regressive" transformation processes and effects on the environment. Hunting of wild animals, burning, ploughing, and grazing seem to be the major processes affecting, sometimes periodically, the natural ecosystems. If intervals between periods of degradation are long enough, ecosystems may eventually regenerate and reestablish themselves. But during the last few decades there has been rapid and intensive extension of all processes leading to degradation in the name of economic development. This new situation resulting from these effects leads to the notion of irreversibility of the degradation processes in question and their effects, and to the distinction between environmental deterioration and desertification. Therefore, we may consider that ecosystems which have lost all, or a significant part of their potential productivity are desertified. Similarly, desertification has been defined by LE HOUEROU (1966) as "a combination of processes which result in more or less irreversible reduction of the vegetation cover leading to the extension of new desert landscapes to areas which were formerly not desert ; these landscapes are characterized by the presence of regs, hammadas and dunal formations". Besides irreversibility we must also take into account the purpose for which man uses the land. An ecosystem can be deteriorated and desertified by grazing, but may however still keeps a good potentiality for agricultural purposes.

A long period of relief from human pressure allows, in most cases, at least partial regeneration and an increase of biological productivity. We can consider as UNEP (1975) "as completely desertified for the purpose of a given land use - any area whose ecosystems are likely to remain at their present minimal productivity level despite twenty-five years (one human generation) of management or protection excluding practices involving massive and costly techniques".

In case of El-Omayed area, although the factors and processes of desertification are quite obvious and easy to describe, it is, however, difficult to quantify its extend and intensity. A number of indicators of desertification can be employed in an attempt to follow these phenomena. Criteria associated with reduction in productivity, proposed by UNEP (1975) are as follows :

- relative reduction in natural plant production in "wet" years ;
- "effective supply" as maximum water reserve in the soil available to vegetation ;
- primary run-off coefficient of the soil.

On the other hand, it is also important, as already suggested, to have criteria associated with irreversibility of degradation. In El-Omaeyd test-area, there is a lack of data for establishing the ecological transformation between various kinds of ecosystem we meet. Therefore, we cannot deal with an analysis of present state of desertification. Beside a static study of desertification, it may be useful to follow the predictable deterioration or regeneration of the test-area under the influence of different levels of intensity of human pressure on the environment.

4.- RESOURCES : PRESENT STATUS, UTILIZATION, POTENTIALITIES.

4.1. CLIMATIC RESOURCES.

Up till now there are only few studies on climatic resources in the western Mediterranean coastal region of Egypt.

According to Table 5 (section 3.1.1.) the duration of bright sunshine in the western Mediterranean coastal region of Egypt, could provide good possibilities of solar energy but there is no utilization at all of this climatic resource in the whole the region. There are differences in the amount of solar radiation received by slopes of different orientations (AYYAD 1971) and comparison between North and South-facing slopes of different inclinations at Alexandria indicates that steep North-facing slopes receive the least amount of radiation.

Wind appears to be a very important source of energy in the region. For instance there is a large number of wells equipped with windmills in Burg El Arab (≃ 526 windmills). This resource is not well developed and only 200 of the windmills were in operation in 1970 (FAO 1970). The same study done by FAO indicates that there were about 1040 wells equipped with windmills through all the region. The use of this resource decreases quickly inland and the development and use of this resource should take into consideration according to the quite constant wind in the region (Table 3).

Intensive investigation should be made on this climatic resource in the coastal region particularly in areas far from cities and where no sufficient infrastructure is available to provide for the needs of life for people.

4.2. WATER RESOURCES.

Historical records, especially during Roman times, indicate that with proper development and management of the available water resources, the northern coastal area of Egypt can contribute a productive part of the Egyptian economy. Romans carried out agriculture development in this zone using water collected in cisterns along the coastal ridges and on the slopes of the plateau, from collecting galleries developed in coastal sand dunes, and probably from shallow wells.

Water studies in REMDENE have been directed towards :

- quantitative and qualitative survey of available water resources,
- developing means of maximizing water use efficiency,
- developing guidelines for solving hydrogeological and salinity problems that may evolve as side effects of water application.

4.2.1 Present Water Resources in the Western Mediterranean Coastal Region of Egypt.

4.2.1.1. Water surface

The available surface water resources in the region are :

- surface runoff,
- runoff of wadis,
- Nile water destined for irrigation of the extension of Mariut project,
- the water carried out by the pipeline between Alexandria and Mersa Matruh. The water carried by the pipe-line is exclusively for drinking, and the Nile water is used only in the area of Mariut extension agricultural project.

Surface water resources of surface runoff and the runoff of wadis are both a direct result of rainfall and depend on its annual distribution and intensity. Runoff is utilized in winter for watering of land. This is accomplished in the three following forms :

a) *Natural winter watering* : Natural watering of land in winter takes place in depressions, where the topographical situation favours the accumulation of runoff of wadis or surface runoff from elevations. The runoff of wadis is spread freely following the slope and accumulate behind natural obstacles (sand dunes or rocky hills).

b) *Artificial winter watering* : Artificial watering is done on small scale by :

- constructing dykes to prevent the flow of runoff of wadis to the sea ;
- constructing dykes in the spreading zones, diverting the runoff of wadis (in some cases spreading is facilitated by the opening of small channels by which the runoff water reaches some isolated fields) ;
- constructing transversal stone or earth barrages in the beds of the small wadis to facilitate sedimentation and create terraces which in general receive abundant runoff from wadis ;
- constructing small dykes parallel to the contour lines to retain the surface runoff. In fact, it is seldom that, such works can be developed with success in this area.

c) *Cisterns* : More than 3000 cisterns dating back to the Roman period exist in the coastal region. They provide the main drinking supply for the people and animals inland. The following Table 20 indicates the number of cisterns in operation in the coastal region and their capacity (FAO 1970).

Table 20. Number of cisterns and their capacity in the coastal region (FAO 1970).

Area	Nb. of cisterns	Capacity	
		Total	Average
Burg El Arab-Hammam	15	2 000 m^3	133 m^3
Dabaa-Fuka	104	30 000 m^3	288 m^3
Mersa Matruh-Negeila	229	120 000 m^3	524 m^3
Sidi Barrani-Sallum	138	63 000 m^3	456 m^3

4.2.1.2. Ground water

Different types of supply are used :

a) *Drilled wells.*

All wells were originally equipped with turbins and pumps. The total annual withdrawal from the drilled wells is estimated to be about 48,000 m^3.

b) *Dug wells.*

There are about 1040 dug wells equipped with windmills.

c) *Collecting galleries.*

The most extensive gallery development is at El Qasr.

4.2.2. Water resources at El Omayed area.

We do not have enough information about the hydrology in the test-area of El Omayed. The main water resources are :

- about 13 cisterns which are used for drinking animals but only few are in operation,
- pipeline which is used for supplying fresh drinking water for people and animals,
- surface runoff which is abundant from Khashm El Eish ridge to the non-saline depression, but needs proper management to make full use of the amounts recieved.

Drilled wells (FAO 1970) which are equiped seem to be unknown in El Omayed area. There is only one well (Fig. 12) where water is of high salinity and was used only during the widening of the main road of the first rocky ridge.

It should be pointed out that the availability of water in soil is modified by topographic and edaphic variations in the region. In general, depressions would receive more than average, and ridges would keep less than average rain water due to run-off. Coarse sandy soils as those of sand dunes may act as storehouses of rain water due to easy penetration of water through non-capillary pores ; water is rarely lost through run-off and evaporation, while considerable amounts of water may be lost on the surface of heavy soil. Thus, it is obvious that soil studies are important in assessing the quantity and the effectivity of water resources.

4.3. SOIL RESOURCES.

Decision-makers need to know constraints on soil use. Therefore, it is advisable to prepare a simple synthetic document which summarizes the main controlling soil factors. In order to achieve this, we adopted a special system for classification of soil resources. Numerous studies proposed various methodologies (e.g. USDA, FAO etc ...), but in our case, it seemed appropriate to apply a system already employed in southern Tunisia which has very similar ecological conditions to our test-area (PONTANIER et VIELLEFON 1977 ; ESCADAFAL 1979 ; MTIMET 1980 ; FLORET et PONTANIER 1982).

Accordingly we may distinguish and map three types of land : irrigable, rain-fed cultivated and noncultivable.

4.3.1. Criteria of land classification.

The soil map is taken here as a basis of mapping of land resources. Topographic, climatic and socio-economic conditions are also taken into account.

Land classification criteria are based on the following five main edaphic variables :

a) *Thickness of penetrable layer* : This determines water supply and the volume of soil exploited by roots. The penetrable layer of soil includes the friable horizons over the bedrock. We consider three thickness classes* :

Thickness > 80 cm (index 1) : Penetrable layer is adequate for good development of root system, and its uptake of essential water and nutrients. The land may be used for irrigated or rain-fed cultivation.

Thickness between 80 and 40 cm (index 2) : Water supply and root system volume are just sufficient for rain-fed cultivation but not deep enough for irrigation (water-logging, asphyxia and salinization hazards).

Thickness < 40 cm (index 3) : The soils of this category are neither cultivable nor irrigable. Only range utilization is possible.

b) *Texture and nature of the penetrable layer* : Texture, particularly of surface horizons, controls the penetration of rain and irrigation water. It has also an effect on erosion, and accordingly on the vulnerability of soil to wind deflation and run-off. In El Omayed area, wind deflation is the main controlling effect, since the texture of soil is mostly sandy, and sometimes sandy silt to silty in salt-affected areas (saline depression).

Concerning the nature of the penetrable layer, the extremely high calcium carbonate content of coastal sand dunes leads to the distinction of two types of sandy layers : excessively calcareous sand (s"), and calcareous sand (s.s').

c) *Nature of the bed-rock* : The bed-rock under the penetrable layer may act as a limiting factor, and may impede deep penetration of the root system and of water. It may be either a pedological horizon as slab (D) and calcareous incrustation (E) the geological bed-rock itself, calcareous sandstone (G), most often in the form of consolidated oolitic dunes.

d) *Salinity* : Salinity in the surface horizon (0-60) becomes a real constraint, especially to rain-fed cultivation, when the conductivity of the saturated paste extract exceeds 8 mmohs-cm. This limit characterises the

* The limits of these classes indicate only the mean depth of soil (± 10 cm).

salsodic class (C.P.C.S.). Beyond a conductivity of 20 mmohs-cm, the constraint is so great that it impedes land cultivation to a great extent. In fact, several factors contribute to determining the threshold, such as texture, slope, water table, and other factors. Thus sandy soils with salinity above 20 mmohs-cm and sometimes more, can be irrigated after salt leaching and setting up a suitable drainage network. Morever, we may distinguish two classes : C1 (conductivity between 8-20 mmohs-cm), and C2 (conductivity > 20 mmohs-cm).

e) Slope :

Slope is an important factor in selecting irrigated areas. If, for example, the slope is between 2-5 %, installations become very expensive. This is also the case with irregular detailed topography. We may represent on the map one class : P : slope between 2-5 % or irregular topography.

In fact the topographic map is not accurate enough to make suitable limits.

4.3.2. Land resources map (Fig. 14).

The combination of the edaphic features and their magnitudes provide a base for the classification of land resources :

a) Class I. Irrigable lands.

Depth > 80 cm, sandy or silty sandy soils in flat areas (slope 0-2%). As a function of soil salinity, we may distinguish :

Class 1a : not sensitive to sterilization by salts,
Class 1b : sensitive to sterilization by salts.

b) Class II. Rainfed cultivable land.

Less deep than previous soils (< 80 cm). They are located in less favourable areas (slope 2 to 5 %, or irregular topography). These sandy soils are always sensitive to wind erosion.

c) Class III. Non-cultivable land.

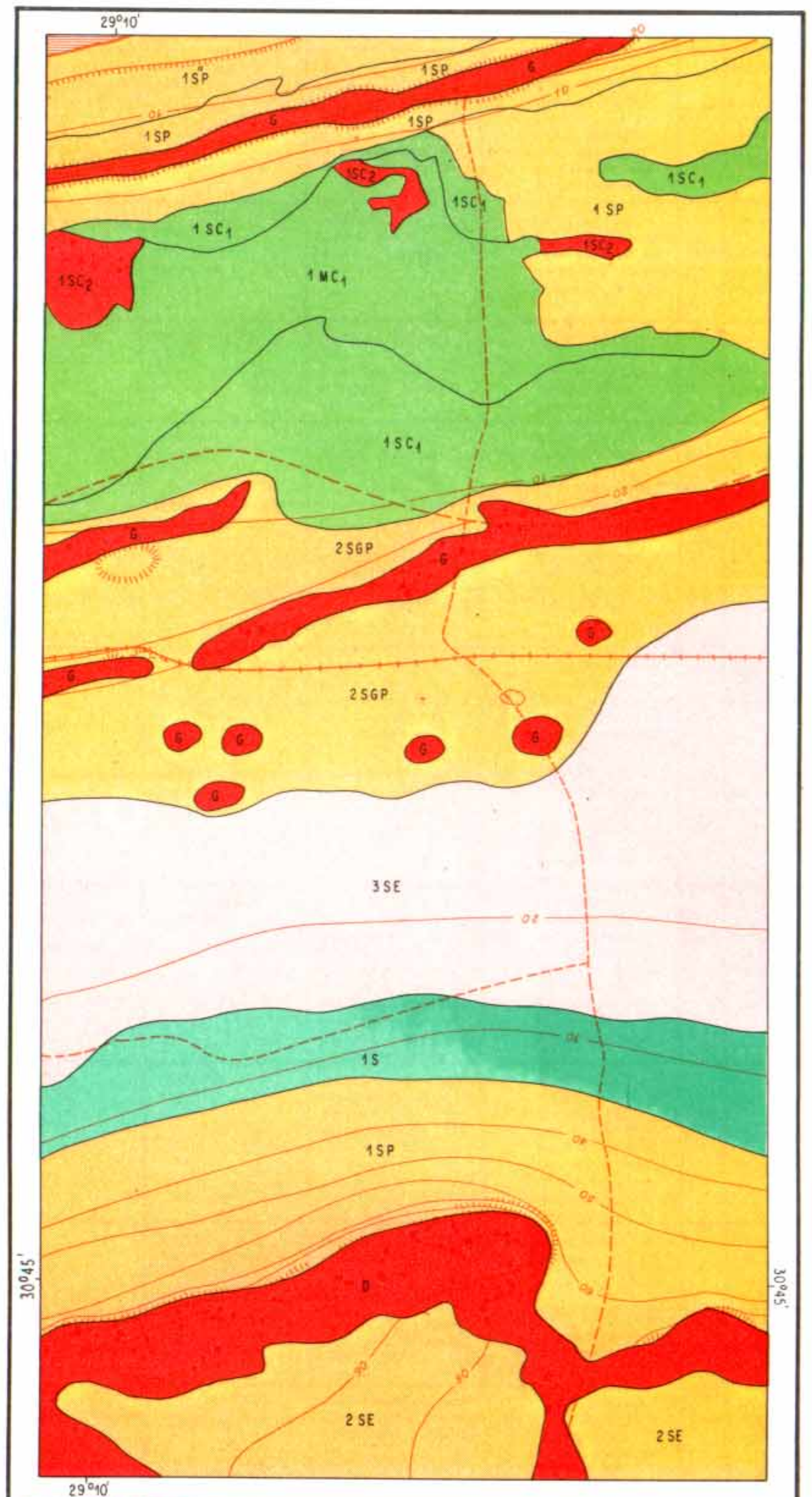
Shallow soil depth (< 40 cm) or excessive salinity (C > 20 mmohs/cm) make cultivation impossible. The only use is for pasture. As a function of soil texture of surface horizon, we may distinguish :

Class IIIa : sensitive to wind erosion,
Class IIIb : not sensitive to wind erosion or salinization, but already degraded.

Each mapping unit (soil family) on the soil map forms a basis for the classification and mapping of land resource units. So the same soil family can be arranged with other families for setting up a land class. A family

POTENTIAL LAND RESOURCES MAP FOR AGRICULTURAL DEVELOPMENT

EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E. L. Emberger.

Scale 1 : 50 000

Contour interval : 10 m

Figure 14

LEGEND

EDAPHOLOGICAL CHARACTERISTICS OF THE DIFFERENT UNITS OF THE LAND RESOURCES MAP FOR AGRICULTURAL DEVELOPMENT

Thickness		1			2	3	Bedrock (rocky out-crop) on the surface	
Texture		S"	S	M	S	S	D	G
Slope < 2 %	Non-saline C<8 mmhos/cm		1S		2 SE	3 SE	D	G
	Saline $8<C_1<20$ mmhos/cm		1 SC_1	1 MC_1				
	Very saline $C_2>20$ mmhos/cm		1 SC_2					
Slope 2< P < 5%, or very irregular topography		1 S"P	1 SP		2 SGP			

CLASSES OF LAND RESOURCES

. Class I. Irrigable land

a — Not sensitive to sterilization by salt

b — Sensitive to wind erosion and sterilization by salts

. Class II. Rainfed cultivable land

Sensitive to wind erosion. Locally irrigable if slope and thickness of the soil allow

. Classe III. Non-cultivable land

a — Sensitive to wind erosion

b — Not sensitive to wind erosion or salinization, but already degraded

EDAPHOLOGICAL FEATURES

Thickness of the penetrable layer

1. $z > 80$ cm

2. $40 < z < 80$ cm

3. $0 < z < 40$ cm

Texture and nature of the penetrable layer

S" . Sandy texture (excessively calcareous sand)

S(S'). Sandy texture (calcareous to very calcareous sand)

M . Silty sand texture (to sandy silt)

Slope (P) :

. $2 < P < 5$ % (or very irregular detailed topography)

. Without symbol : $P < 2$ %

Nature of the bed-rock

D . Calcareous slab

G . Limestone (consolidated oolitic dune)

E . Calcareous incrustation over calcareous sand stone

. Without symbol : the bedrock does not appear to 120 cm depth

Conductivity (C) of saturated paste extract (0 - 60 cm)

C_1. $8 < C_1 < 20$ mmhos/cm

C_2. $C_2 > 20$ mmhos/cm

. Without symbol : $C < 8$ mmhos/cm

TABLE 21 : SYNOPTIC TABLE OF GENERAL ECOLOGICAL CONDITIONS AND LAND RESOURCES

PHYSIOGRAPHIC SYSTEMS	PHYSIOGRAPHIC UNITS N°	UNIT	PRESENT LAND USE	SOILS	EDAPHOLOGICAL CHARACTERISTICS SYMBOL	CHARACTERISTICS	CLASS	POTENTIAL LAND RESOURCES LAND RESOURCES
COASTAL SYSTEM	1	Beach						
		Coastal sand dune	uncultivated land	Raw mineral soil over excessively calcareous sand dune (Typic torripsamments)	1S"P	Deep and very sandy soils with more of 80% calcium carbonate - very irregular topography	II	Rainfed cultivable land (planting fig-trees without ploughing) ; very sensitive to wind erosion, fixation of dune with *Elymus farctus*
RIDGES AND DEPRESSIONS SYSTEMS	3 4 6	First depression Northern slope of the first rocky ridge Southern slope of first rocky ridge	Fig-trees, pastures	Slightly evolved soils ; modal grey subdesertic soils over very calcareous sand (Typic torripsamments)	1SP	Deep sandy soil with 30-50% of calcium carbonate ; slope between 2-5% and more (except in the first depression)	II*	Rainfed cultivable land (fig-trees, cactus) sensitive to wind erosion. Locally irrigable in the first depression
	5 8 10	First rocky ridge (1RR) Second rocky ridge (2 RR) Third rocky ridge (3 RR)	Human settlement, pastures	Lithosol over limestone (Lithic torriorthents)	G	Very shallow soils (< 40 cm) with outcrop of limestone (consolidated oolitic dune)	III_b	Non cultivable land not sensitive to wind erosion but already degraded
	7a	Salt marsh	Halophytic plant (*Halocnemum* sp.)	Salsodic soils : very saline with degraded structure (Typic salorthids)	$1SC_2$	Conductivity > 20 mmhos/cm. Shallow saline water table (about 1m.deep)	III_b	Non cultivable land Not sensitive to wind erosion
	7b	Hummocky depression	Pastures, barley	Salsodic soils (Typic calciorthids)	$1MC_1$	Conductivity between 8-20 mmhos/cm ; silty sand texture	Ib**	Irrigable land sensitive to wind erosion and to sterilization by salts
			Pastures	Slightly evolved soils = saline grey subdesertic soils (calcic gypsiorthids)	$1SC_1$	Conductivity between 8-20 mmhos/cm mainly under 50-60 cm depth. Sandy texture (with silty gypsiferous sand)	Ib***	Irrigable lands sensitive to the wind erosion and to sterilization by salts
	7c	Sandy mesodeposits	Fig-trees	Slightly evolved soils = modal grey subdesertic soils (typic torripsamments)	1SP	Deep sandy soils (slightly saline about 2m deep and more). Very irregular topography and often slope between 2-5%	II	Rainfed cultivable land (fig-trees). Very sensitive to wind erosion
	7d	Sandy indurated convexities	Human settlement	Lithosol over limestone (lithic torriorthents)	G	Very shallow soils (< 40 cm) with outcrop of limestone (consolidated oolitic dune)	III_b****	Non cultivable land
	9 11	Inter-ridges sandy slopes Southern sandy slopes	Fig-trees, pastures	Slightly evolved soils - modal grey subdesertic soils, locally moderately deep lime accumulation in amas and nodules, sometimes calcareous incrustation. (Typic torripsamments)	2SGP	Moderately deep sandy soils over consolidated oolitic dune (between 40 and 80 cm depth, sometimes more or less). Slope between 2-5%.	II*****	Rainfed cultivable land (fig-trees, cactus), locally irrigable when slope < 2%. Very sensitive to wind erosion
	12	Non saline depression	Pastures	Calcimagnesic soils with calcareous incrustation (Typic calciorthids)	3SE	Shallow sandy soils over calcareous incrustation and shelly hard sandstone (about 1m depth). Often salt-affected in depth	IIIa	Non cultivable land sensitive to wind erosion. Range management
	13	Sandy glacis	Pastures and fig-trees (fans at the foot of gullies)	Slightly evolved soils = modal grey subdesertic soils, locally moderately deep calcareous accumulation in amas and nodules (Typic torripsamments)	1S	Deep sandy soils slope < 2%	Ia	Irrigable land Not sensitive to the sterilization by salts but sensitive to wind erosion
					1SP	Deep sandy soils ; slope between 2-5% with gullies	II	Rainfed cultivable land (fig-trees, cactus). Very sensitive to wind erosion
INLAND PLATEAU SYSTEM	14	Cliff and outcrop of Inland plateau	Pastures	Calcimagnesic soils with calcareous slab (Typic paleorthids)	D	Very shallow soils over calcareous slab, locally saline by patches	IIIb	Non cultivable land Not sensitive to wind erosion
		Undulating sandy surface		Slightly evolved soils = modal grey subdesertic soils, moderately deep calcareous incrustation (typic torripsamments)	2SE	Moderately deep sandy soils over calcareous incrustation (between 40 and 80 cm depth sometimes more or less)	II******	Rainfed cultivable land sensitive to wind erosion

* Laterally some salt marsh in the first depression
** Drainage and leaching of salts will be required
*** Drainage will be required . Type and frequency of irrigation and crops have to be adapted to this type of soil
**** Very small areas
***** - almond-tree - olive-tree
****** Rainfall seems not sufficient for fig trees or cactus. Good pasture.

could also share others in several classes (as a function of slope for instance).

Each class on the map of land resources is represented with a specific colour, as an index which sums up levels of the five main edaphological features.

The Table 21 gives a synoptic view of ecological conditions and land resources.

4.4. PLANT RESOURCES.

4.4.1. Rangelands.

The standing crop of above ground phytomass was estimated during october 1982 (which represents the end of the long grazing and dry period) using 100 randomly distributed quadrats, each of 4 m^2. In each quadrat, all the above ground organs were harvested except three shrubby species whose phytomass was estimated through a relationship between phytomass and dimensions. The harvested organs were weighed after cleaning in the field, and the samples were brought to the laboratory for water content determinations.

The dimensions of the shrubby species were converted to weights using the following regression equations :

Thymelaea hirsuta equation (SHALTOUT, in prep.)

$$y = 35.69 + 0.001\ x$$

Anabasis articulata equation (ABDEL-RAZEK 1976)

$$y = 0.363 + 0.6\ x$$

Limoniastrum monopetalum equation (calculated for the present study)

$$y = 0.154 + 0.079\ x$$

where :
- . x is the biovolume of the shrub in cm^3 in case of the first equation and in m^3 for the other two equations
- . y is the above ground phytomass of the shrub in gr. dry weight in the case of the first equation and in kg. dry weight for the other two cases.

This estimation is used to evaluate the highest and lowest seasonal production according to the rate of the seasonal variation in the standing crop phytomass which was calculated from EL GHAREEB (1975), EL BAYYOUMY (1976) and AYYAD *et al.* (1979). The difference between the highest and lowest seasonal values gives the approximate value of the net primary production (primary production after heterotrophic consumption) in mean rainfall conditions. Results are shown in the map and the legend of Figure 15. The relative contribution of the common species in the total above ground phytomass is given in

PLANT RESOURCES MAP

EL OMAYED TEST-AREA

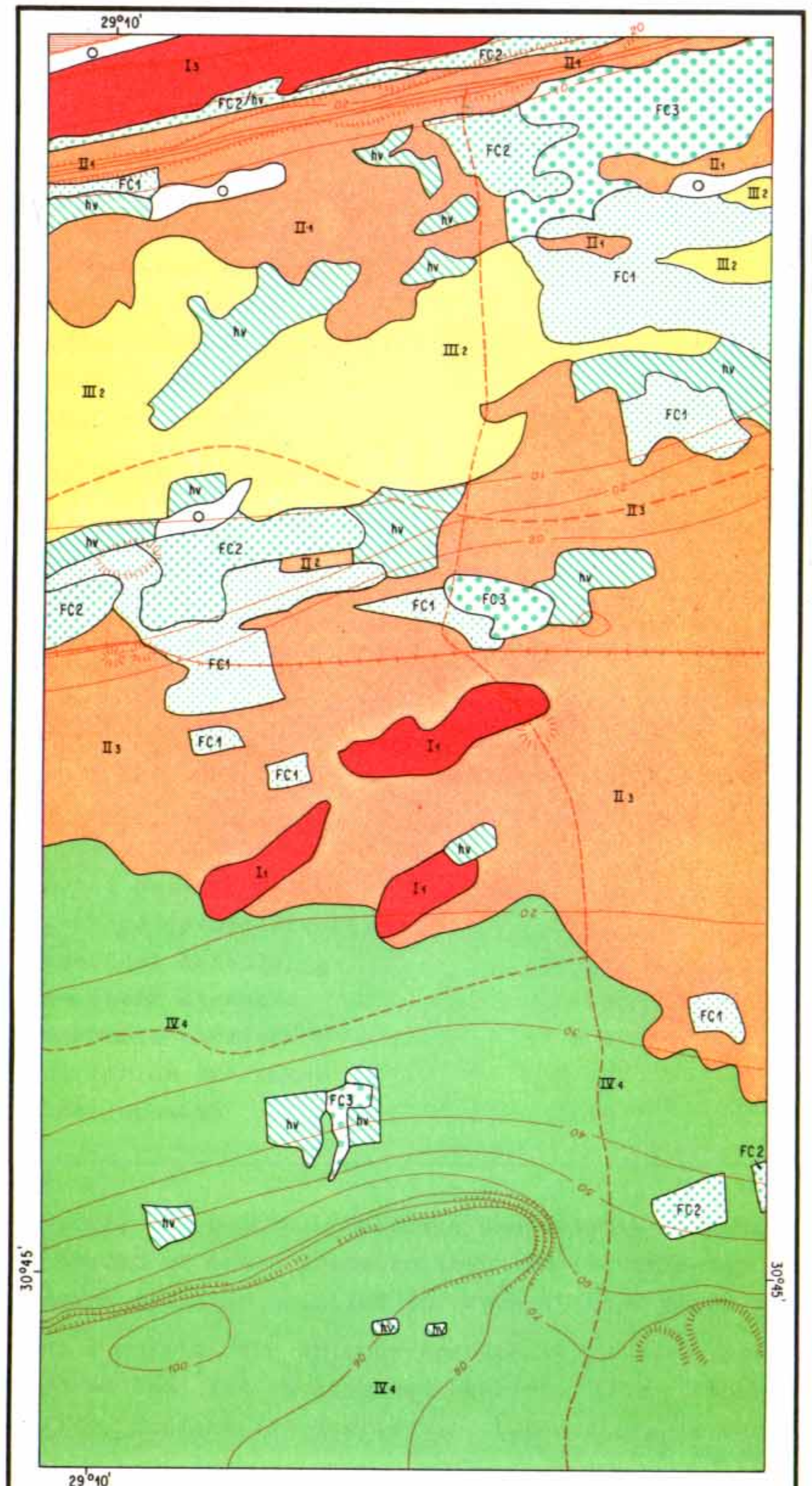


Figure 15

LEGEND

PLANT RESOURCES MAP

RANGELANDS

TOTAL ABOVE GROUND PHYTOMASS (october 1982)		NET PRIMARY PRODUCTION (in average rainfall conditions)	
Class (kg. dry matter/hectare)	Code	Class (kg. dry matter/hectare/year)	Code
< 250	I	< 60	1
250 - 450	II	60 - 80	2
450 - 650	III	80 - 100	3
650 - 850	IV	100 - 120	4

ORCHARDS (figs)

TOTAL ABOVE GROUND PHYTOMASS (excluding fruits)	NET PRIMARY PRODUCTION (fruits only in average rainfall conditions)	
Class (kg. dry matter/hectare)	Class (kg. fresh weigh/hectare/year)	Code
< 4000	< 300	FC1
4000 - 8000	300 - 1300	FC2
8000 - 12000	1300 - 2300	FC3

CROPPING LANDS (barley)

TOTAL ABOVE GROUND PHYTOMASS and NET PRIMARY PRODUCTION (in average rainfall conditions)

For barley is it obvious that the Net Primary Production is also the Total Above Ground Phytomass (in kg. dry matter/hectare/year) Total weight ≃ 430 kg. (grain : 145 kg.; straw : 285 kg.)	hv

N.B. : On the map the color is given for the class of Total Above Ground Phytomass. Each unit is however described with the two symbols of its Total Above Ground Phytomass (T.A.G.P.) and of its Net Primary Production (N.P.P.) : i.e. for Rangelands symbols II3 (unit in pale green on the map) means that the T.A.G.P. is about 250-450 kg. dry matter/ ha . and that, in addition, the NPP is about 80-100 kg. dry matter/ ha./year.

Table 22.

Table 22. Relative contribution of the common species in the above ground phytomass.

. non saline rangelands

species	relative contribution % of total weight
Anabasis articulata	54
Echiochilon fruticosum	21
Thymelaea hirsuta	12
Gymnocarpos decandrum	5
Asphodelus microcarpus	4
Helianthemum lippii	1
Plantago albicans	1
other species	2

. saline rangelands

Limoniastrum monopetalum is the most dominant overwhelmingly in all area and it contributes with 70-80% of the total above ground phytomass. *Anabasis articulata, Plantago albicans, Salsola tetragona, Halocnemum strobilaceum, Arthrocnemum glaucum, Noaea mucronata* and other species complement the total above ground phytomass in this area.

. coastal dunes

species	relative contribution % of total weight
Crucianella maritima	34
Ononis vaginalis	12
Echinops spinosissimus	11
Thymelaea hirsuta	10
Ammophila arenaria	9
Euphorbia paralias	4
Pancratium maritimum	2
other species	18

Present total above ground phytomass and relative contribution of each species are the result of human pressure (man and its animals) on the rangelands. These species are also utilized for several uses other than grazing :

. As fuel : most of the shrubby species, in the area are cut and harvested to be used as fuel for cooking and heating, like : *Thymelaea hirsuta, Anabasis articulata, Echiochilon fruticosum, Gymnocarpos decandrum, Lycium europaeum*... etc.

. For protection : bedouins use shrubs as shelters for young fig plantations to prevent grazing by animals and against sand accumulation. Near the coastal dunes somes species like *Ammophila arenaria* and *Elymus farctus* are used for the same objective. Near houses *Thymelaea hirsuta* and *Lygos raetam* are sometimes used to provide shelter for animals.

. For hunting : the hunting of migrating birds is extensive in the litoral part of the study area, while it is insignifiant in the inland part. The bedouins use some plants like *Thymelaea hirsuta* and *Lygos raetam* (and in some cases olive trees) covered with nets as traps for migrated birds. The most important captured migrating birds is the "quail" (*Coturnix coturnix*) which is eaten.

4.4.2. Cultivated plants.

For barley fields, grain and straw are weighed during the harvesting period. For figs, trees are carefully chosen to represent three sizes (small, medium, and large) then were cut and weighed. For each unit in the map (Fig. 15) results expressed per hectare are given according to the size of the trees and their density, after classifying them into three classes of total above ground phytomass (including fruits).

4.5. ANIMAL RESOURCES.

Even if hunting provides some possibilities, we consider only here resources offered by domestic animals. The two main domestic species are : sheep and goats.

We must first keep in mind, as it was already described (see section 1.5), the fact that the grazing period is only nine months (from October to June) ; after which almost all herds leave to be fed in other areas (Tahrir and Nile Valley).

Our aim is to estimate in relation to the present stocking rate (assessed by inquiries), the actuel present carrying capacity. Such notion of the present carrying capacity expressed as a means to conserve vegetation from severe damage and to improve production of herds through a good balance between their requirements and the consumption of energy (concentrates and edible plants on rangelands) during the grazing period.

In order to calculate the amount of consumption during grazing of natural vegetation the grazed species were identified and the number of bites and the duration of grazing and resting are recorded (EL KADY 1980). At the end of each season 20 bites of different species were sampled and used to estimate the average of fresh and dry weights of one bite. The fresh and dry weight consumed in the various situations of El Omayed area were thus calculated. It has been also observed that during the grazing period animals also eat litter of some species (mainly *Helianthemum lippii*, *Anabasis articulata*, *Thymelaea hirsuta*). The preliminary estimation of the necromass (or litter) indicates that each animal takes an average of 150 mouthfulls of litter/day (≃ 150 gr. dry matter/day) during the dry season and about 50 mouthfulls/day (≃ 50 gr. dry matter/day) during the growing season . Table 23 includes the results of these measurements for El Omayed from 1978 to 1980.

Table 23. Consumption of above ground phytomass and of necromass for some physiographic units of El Omayed area during the 9 months of the grazing period (kg. dry matter/animal).

Physiographic units (see Fig. 3)	kg of dry matter consumed/9 months/animal		
	above ground phytomass	necromass	total
4-5-6-7b	≃ 205	≃ 26	≃ 230
9-11	≃ 175	≃ 26	≃ 200
12	≃ 200	≃ 26	≃ 225
13-14-15	≃ 240	≃ 26	≃ 265

During the last three months of the year (October, November, December) and the spring (April, May, June) supplementary feed is given to the animals (about 0.25 kg/head/day of concentrate composed of cotton seed cake, barley grains and bran). This supply is increased in the saline depressions and in the area near the coast to 0.5 kg/head/day of concentrate. In fact, during the last few years bedouins changed their behaviour by increasing the part of supplementary feed to ≃ 0.5 kg/head/day through the whole grazing period due to low rainfall and the damage of vegetation. This 0.5 kg/day/head of concentrate (of value more or less similar to the caloric value of barley grains) is accepted here as covering 65 % of the dayly requirements of one head of animal (1 sheep, 45 kg weight).

We also suggest that the caloric value of 3 kg of dry matter of natural vegetation is equal to that of 1 kg barley grains (1 kg dry matter ≃ 0.33 kg barley grains). It appears that in addition to the 0.5 kg/day of concentrate (65 % of daily requirements) each animal must consume 1 kg dry matter on rangelands (≃ 35 % of daily requirements) for covering its needs of energy. During the grazing period (275 days) each animal must consume 275 kg dry matter on rangelands. By comparison with Table 23 we can see that the observed daily consumption (taking into account the error of measurements for consumption in steppic conditions) is approximately in accordance with the requirements, even if we can consider that animals are probably a bit underfed.

Since we know the annual net primary production of the main physiographic units of El Omayed area (see Fig. 15, section 4.4.) it is also possible to compare it with the present consumption/head/grazing period (or with the dry matter requirements), and to obtain the present carrying capacity. The following map (Fig. 16) and its legend include these data.

Using the information included in this map and its legend we may estimate that the total of animals that can be supported in this area is about 1065 heads. In fact, this carrying capacity is calculated as a means to improve progressively the vegetation cover, the net primary production and of course the carrying capacity. However the present carrying capacity (1 animal/ 4.2 ha on the average) is at least 5 times less than indications provided by inquiries for the present stocking rate (1 to 1.5 head/ha according EL KADY 1980, and according to the results expressed in section 1.5). So, great difference may be due to different reasons :

- heads owned by people living in El Omayed area are also sometimes grazing out of the study area (i.e. inland) ;

- here the carrying capacity is calculated for one head of adult sheep but in the herd there are such animals as lambs, kids ... with least requirements.

For each household, it is also possible to found some other animals like rabbits and pigeons, but their participation in animal resources seems to be small.

4.6. HUMAN RESOURCES (LABOUR FORCE AND INCOME).

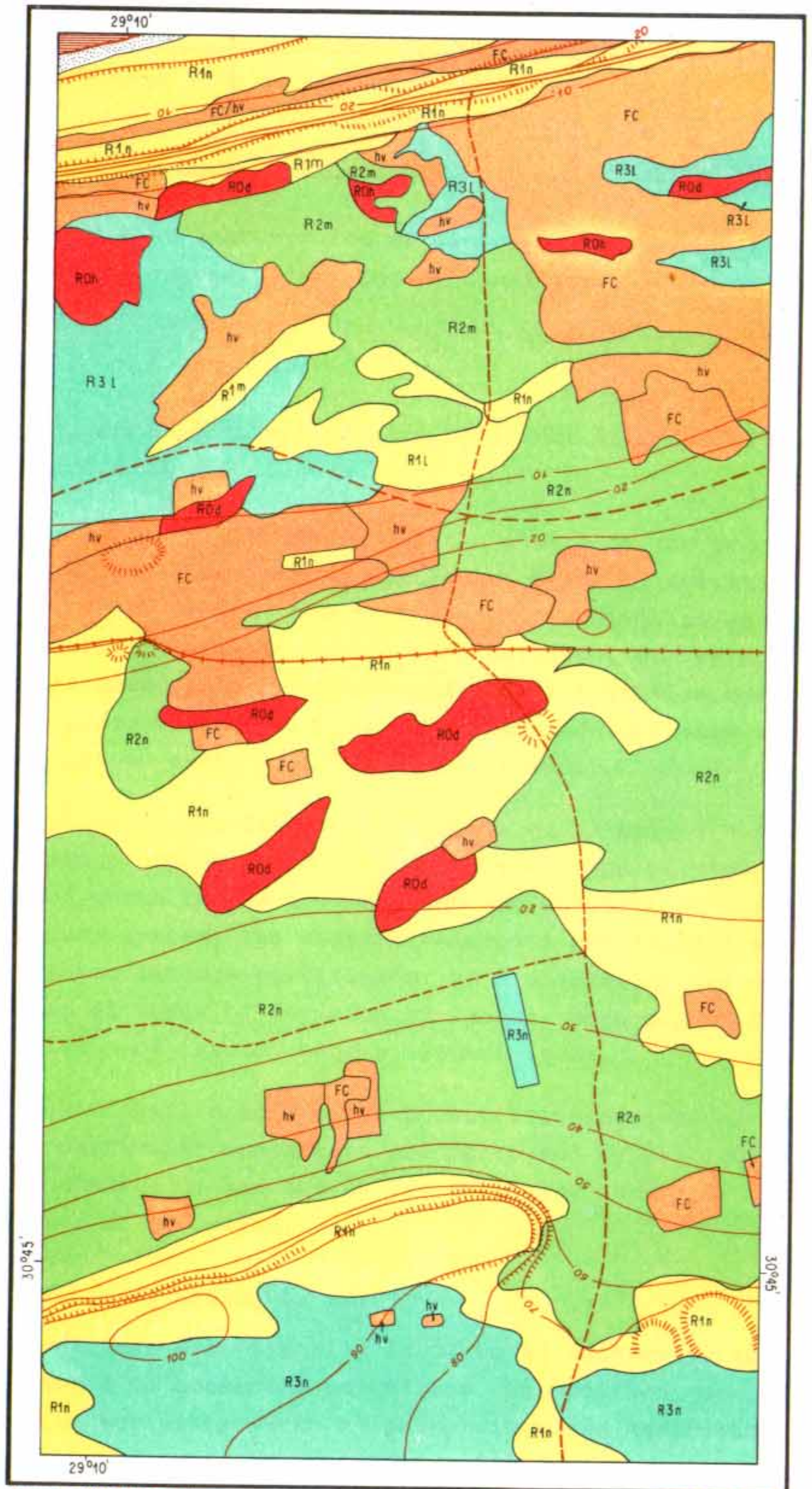
As already shown in section 3.1.5.1. the size of population in El Omayed area and vicinity is about 1400 persons . These people are not active relative to the expected differences in age, sex and present kind of activities. We can characterize this population through the distribution of such parameters indicated hereafter and try in this way to explain the labour force availability.

4.6.1. Labour force at El Omayed and vicinity.

We mean by labour force the capacity to execute a certain labour in the framework of a production process. This capacity may be physical, as well as intellectual.

Depending on the results of our study of 25 households, and taking into consideration that between the ages of 7 to 15 years labour can be evaluated as a fraction of the productive capacity of an adult labour (Inst. Agron. et Vét. Hassan II RABAT 1979), we calculated the labour force in El Omayed and its distribution between the three sub-tribes (Table 24).

CARRYING CAPACITY MAP
EL OMAYED TEST-AREA



Drawn Jan. 1983 C.E.P.E. L. Emberger.

Scale 1: 50 000

Contour interval : 10 m

Figure 16

LEGEND

PRESENT CARRYING CAPACITY MAP

Code	Designation	Carrying capacity (1 animal for)	Area (hect.)
ROd	Rangelands completely degraded	> 10 hect.	79
ROh	Rangelands of highly halophytic vegetation		
FC	Orchards (figs leaves and branchs)	≃ 10 hect.	918
hv	Barley fields (stubbles and weeds)		
R1n	Rangelands of non halophytic vegetation under high level of overgrazing	≃ 6 hect.	1110
R1L	Rangelands of less halophytic vegetation under high level of overgrazing		
R1m	Rangelands of moderately halophytic vegetation under low level of overgrazing		
R2n	Rangelands of non halophytic vegetation under low level of overgrazing	≃ 4 hect.	2221
R2L	Rangelands of less halophytic vegetation under low level of overgrazing		
R2m	Rangelands of moderately halophytic vegetation undergrazed		
R3n	Rangelands of non halophytic vegetation, undergrazed	≃ 3 hect.	650
R3L	Rangelands of less halophytic vegetation undergrazed		
(Beach)	Beach	no applicable	17

Table 24. Assessment of distribution of inhabitants and labour force (unit = 1 man) for sub-tribes in El Omayed and vicinity (inquiries on 25 households in 1982).

Sub-tribe	Nb of inhabitants	Nb of "men labour force"
Abou Shinaïna	700	280
Shtour	400	150
Ahmed	300	120

We may add that labour force estimated here represents in fact a theoritical concept because, according to traditions, women are not available for all kinds of work.

4.6.2. Division and distribution of labour in El Omayed test-area and vicinity.

Division of labour, according to the nature of the economic activities is the specialization of workers in particular parts of operations of a production process. At El Omayed, the main economic activities are pastoralism, agriculture and other small activities such as trade, quarrying etc.. This specialization is based on a certain professional formation acquired by study, practice or training. The division of labour depends not only on economic considerations, but on every other sphere of society.

In the study of the division of labour at El Omayed, we shall take into consideration : economic and social systems, type of production, the status of man and woman in the society, the social value of every activity the dominant values system, the cultural elements and traditions and general concensus. All these factors participate, to a greater or lesser degree, in the determination of types of division of labour. When any of these factors change, the division of labour changes (ISMAIL 1976).

This chapter will describe the productive processes of every activity and explain how particular operations are performed by particular individuals on the basis of their age, sex and skill, which are the major criteria of the division of labour at El Omayed.

a). Division of labour by sex.

In general, men are primarily involved in productive activities, and women are restricted to household activities. In addition, women participate in some productive activities such as pastoralism and agriculture. This participation varies according to the economic activity.

Women participate, as well as men, in some operations of the grazing process such as taking the animals from the house to the near pasture areas, foddering, watering, medical treatment, and keeping. Milking and artisanal operations such as making wool carpets, making cheese and butter are done only by women. Women participate also in harvesting of figs. All the households activities as cleaning, cooking, raising children, bringing water and collecting firewood are done by women.

Man are involved in herding, which may take place near or far away from the house, or in the Delta during summer. Herding may be done by family labour force, or waged labour force. Also, shearing of animals is a kind of work which is done only by men, and it is done mostly by waged workers. At the end marketing is done by men.

We find that levelling of soil, ploughing, seeding, weeding and pruning are done only by men, who may be waged workers or family workers according to the size of the farm relative to the size of the family. Meanwhile, as women, men are involved in harvesting. Waged labour force of men participate in this process. Marketing of crops is done only by men. All other activities such as trade, driving, working at quarries and gypsum plant are done only by men.

We may point out that there is no rigid sex distribution of labour, but an overlapping between role and function. Moreover, division of labour by sex is too complicated to be explained only by physiological differences between man and woman. It is determined as function of the dominant values system, the status of man and woman in the society, the social value of every work, traditions ... etc. In other words, it is determined according to a complex combination of factors which determines what is called the dominant economic and social system.

b). Division of labour by age.

This varies according to the economic activities. Children who do not go to school, or who leave it at an early age are involved in herding, watering and foddering animals near the houses. For rural children (both girls and boys) participate only in harvesting of crops (figs,seed melon, water melon). Only young ladies participate in herding animals, harvesting of crops, bringing water and collecting fire wood, meanwhile all women (including yound and old) help or take care of foddering, watering and milking animals. All women also do the handcraft and other domestic activities (cooking, cleaning ...). Young men participate all kinds of activities of men but they are specially involved in activities (transportation,quarrying, trading etc ..) which require physical strength.

Men are generally involved in all processes of pastoralism (apart milking, making cheese and butter) and of agriculture. However, the agricultural activities levelling of soil, ploughing, seeding, weeding, harvesting and marketing may be done by waged labour force of men as well as family labour work force. Harvesting of barley is always done by waged workers. Meanwhile, old men are responsible for the agricultural processes which need a special expertise such as pruning. They also supervise the activities of the members of the family.

c). Division of labour by skill.

At El Omayed, this base of division of labour plays a very limited role as a result of the lack of diversity of economic activities. This pattern of division of labour exists in the quarries and gypsum plant where the use of machine is extended, every worker specializes in a certain part of the production process. The work in quarries and the gypsum factory is done by waged men.

Also, there are many households with cars, tractors, and trucks to meet the requirements of extended fig cultivation. In these households one or more of the members are experienced drivers. They practice the work for the household and for others. This work does not prevent them from practicing other activities. In agriculture, the division of labour technically is shown in the process of pruning and, in pastoralism,it is shown in the process of shearing.

After analyzing the division of labour at El Omayed according to the major criteria, we may conclude that every one practices his activities without rigid specialization. So the division of labour is based mainly on purely physiological foundation ; age, sex and traditions. Since the degree of technological complexity, which is measured by machines and utilised energy, is simple, we find that the qualification of workers comes from a complex and diversified knowledge which is obtained through practice, and consequently the difference in skill is small.

Distribution of labour force according to the economic activities reflects the type of dominant economic structure, and its degree of development. The study of 25 households demonstrated the type of distribution (Table 25).

Table 25. Assessment of the distribution of labour force according to the different kinds of activities, in El Omayed test-area and vicinity (results of inquiries on 25 households in 1982).

* Labour force : number of men

Type of activity	% Inquiries	Assessment* for El Omayed test-area and vicinity
Pastoralism, agriculture	78.4	431
Transportation	6.4	35
Trade and services	5.4	30
Quarries	4.5	25
Gypsum plant	4	22
Construction	1.3	7

We may then conclude that the relative importance of pastoralism and agriculture is great. The preliminary field study indicates that, probably about 60 % of labour force is engaged in pastoralism. In these kinds of economic activities the relation between man and nature is a direct one, where the role played by nature in the production process is obvious.

4.6.3. Income distribution.

We have no data concerning income distribution, but our field study indicated that pastoralism was the main source of income at El Omayed (Fig. 17). With time,agriculture is becoming the principal source of income and the role of other activities is increasing. We may add that the main sources of income are now in the following decreasing order : agriculture, pastoralism and other activities.

We may emphaze also that an increasing part of income is being reallocated in the expansion of fig cultivation since its return is increasing We may add that the relative part of income which is reallocated in agriculture is more than that which is reallocated in pastoralism and other activities.

Because rain plays an important role in agriculture and pastoralism and determine the yield, we may conclude that the level of income in both is characterised by uncertainity. This fact justifies the trend to diversify the activities and accordingly the sources of income.

Research is needed to assess the contribution of every activity to the income of every household and the factors which determine such contribution.

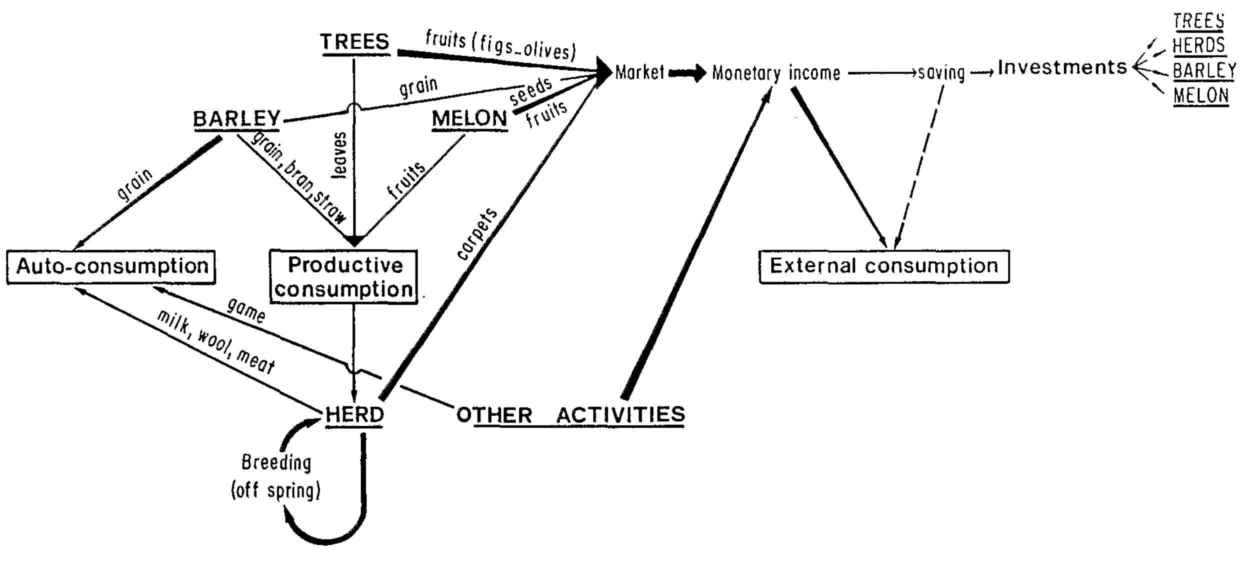


Figure 17 _ ECONOMIC FLOWS IN THE DIFFERENT SUB-SYSTEMS OF PRODUCTION (REAL AND MONETARY FLOWS) IN EL OMAYED · TEST AREA

5.- RURAL AGRICULTURAL DEVELOPMENT : SCENARIOS AND CONSEQUENCES.

The current evolution of various criteria and parameters proposed for the description of the ecological conditions in the study area as demonstrated in section 3.3. indicates that the present level of human pressure is leading to significant deterioration of its environment. The study of the effect of human practices and their economic impacts on the evolution of ecosystems in terms of components and resources, may provide very useful information for land managers and decision makers concerned with optimal allocation of resources and rural agricultural production. Through appropriate incitement, land development may, in fact, contribute to the improvement of agricultural practices, and improve the evolution of ecosystems.

The primary aim of this section is to propose a tentative model which may give some information to planners, and indicates consequences of implementation of various scenarios of development of land resources in the study area. The proposed model simulates trends of variation in ecological conditions due to different land-use plans.

5.1. SELECTION OF LAND-USE SYSTEMS AND LEVELS OF LAND-USE INTENSITY.

The following are five scenarios which may be proposed for potential land development in El-Omayed test-area, and which represent increasing levels of human pressure.

a). Level 1 : Full protection.

This scenario is unrealistic. It is proposed only for comparison of economic variables with those of other scenarios. It implies the prohibition of ploughing, and stopping on a short term basis of all human practices including wood cutting and all activities related to domestic animal production.

b). Level 2 : Rangeland development and limitation of the area of ploughed fields.

This scenario implies that cereal cultivation and tree plantation would be limited only to suitable areas : (a) areas with "negligible", "low" or "medium" degree of vulnerability of natural plant cover and of soil which has to be ploughed (see Table 18), and (b) areas where the topography allows for water harvesting and which consequently have better yields, mainly for cereals. This scenario implies also the adjustment of stocking rate on the ranges to the present grazing capacity, and to ensure the recovery of the plant cover by rotation in depleted areas. In this case, it becomes impossible to depend only on natural grazing resources for feeding animals, and it becomes necessary to have supplementary feed during the transitional period preceding the complete restoration of ranges.

c). Level 3 : Continuation of present practices and maintenance of present land-use system.

Current practices indicate that with the present system of cereal cultivation and tree plantation yields will remain low. Locations used for grazing will be gradually overgrazed and will decrease in area. Continuation of the present practices means in fact more ploughing for cropping and extention of orchards. This scenario means also an increase in the number of animals and means no planning for managment of rangelands (e.g. limitation of stocking rate according to the level of production of rangelands). Although this scenario is the most probable, it will result in immediate limitations for land use. For instance, the harvesting of large areas of low yield cereals by hand is a bottleneck, since it will be difficult at present to visualize the introduction of mechanized harvesting in such low yield condition.

d). Level 4 : Intensification of present practices.

This scenario postulates that :

- the recent and fast extension of orchards for economic reasons will still increase during the next twenty five years,
- socio-demographic conditions necessitate new extension (due to possibility of mechanization) of cropping for human consumption and for feeding of animals ;
- investments are made for promoting the use of resources (e.g. increasing the number of watering points) with no acceptance by the population of the principle of rational range management (stocking rate, rotation, etc ...).

e). Level 5 : Introduction of irrigation water.

Such scenario of development must be evaluated according to the environmental potentials (see section 4.3.) and availability of the local labour force (for instance the required manpower for cultivation of irrigated alfalfa is approximately eighty days/year/hectare). This scenario may provide a possibility for regional development if good yields are attempted for cereals and various fodder crops, and if a limitation of animal stocking rates on rangelands is achieved simultaneously. Environmental conditions must be considered very carefuly in order to avoid salinization and water-logging.

5.2. ELABORATION OF AN ECOLOGICAL MODEL FOR PLANNING AND MANAGEMENT OF RURAL AGRICULTURE.

Conceivably, the objective is not to choose one of the five scenarios mentioned above but is to inform the planners about the consequences of implementation of each of these scenarios. We should mention that our understanding about several elements is still not adequate enough to answer all questions. In view of the absence of relevant data concerning some variables, this section deals only with the methodological approach of building up such an ecological model. Meanwhile, such model will demonstrate what we can offer using the already collected data, and at present to provide some proposals which may help in conceptualizing and building up of models that simulate the trends of different land-use conditions.

The following are the main phases of the proposed model :

5.2.1. Inventory of the present conditions.

Studies of the natural environmental variables in the test area are numerous. There are however, some gaps concerning primary production, water resources of soil (soil moisture) in different years and in different soil types, and computations of the probabilities of occurrence of annual or seasonal rainfall for a given period. Such probabilities of rainfall pattern may help in the classification of the patterns of annual rainfall with typical seasonal distribution (considering also very important data such as the beginning and the end of the rainy season) ; such data may also enable us to predict annual and seasonal evolution of plant production (natural and man-made) in relation to fluctuations in climate and soil moisture content. The thematic maps prepared using aerial photographs and field observations allow for the extrapolation of the present state of the test-area described for some plots to similar types of ecosystem.

5.2.2. Studies of possible evolution from the present state.

All degradation processes may entail relationships between different units of the test zone due to the topographic location ; the lowest units receive water from neighbouring slopes by run-off, and soil elements by erosion. In the meantime, the same unit may suffer from deflation which results in carrying its soil to be deposited later in another unit. Using the aerial photographs of different dates (1954, 1962 and 1979) for El-Omayed test-area, it may be possible to compare successive states of land, the rate of transformation of one unit to another. In certain land-use systems we can visualize level 3 ("continuation of present practices and land-use system"). Other cases can also help in understanding the evolution in the case of level

1 ("total protection environment"). When it is impossible to obtain information from field experiments, we can make informed guesses about what may happen, taking into account all what is known about the area.

5.2.3. Utilization of transition matrix.

The principle is to use the method of "transition matrix" (GODRON and LEPART 1973) where coefficients are given as percentages of the probability of change from one unit (or one yield) to another according to different hypothesis (i.e. selected systems and level of land use intensity). The "transition matrix" indicates for successive intervals of five years, for instance, according to level 3, the part of each unit transformed from range to field crops, since the speed of extension ("transformation") of cultivation is variable from one unit to another according to their relative attractivity for this practice (see Table 18). Accordingly, starting from the present state,where the surface of each unit is known, it is possible, using automatic computer, to predict for each five-years time increment, the areas occupied by each type of ecosystem. The combination of the results of "transition matrix" (areas of each type of ecosystem and land-use) and of the primary production model (as proposed before), according to the climatic fluctuations, enables us to estimate the evolution of different resources in the whole area during a long period (25 years for instance), and for the different levels of human pressure indicated before.

5.3. CONSEQUENCES OF THE PROPOSED SYSTEMS.

The consequences of different scenarios may be analyzed as :

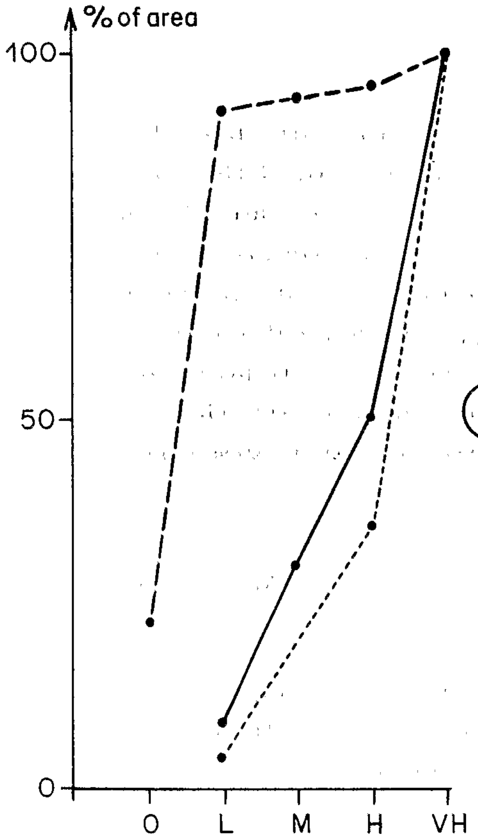
- impacts on main ecological features,
- effects on the future of resources,
- results concerning socio-economic situation of land-users.

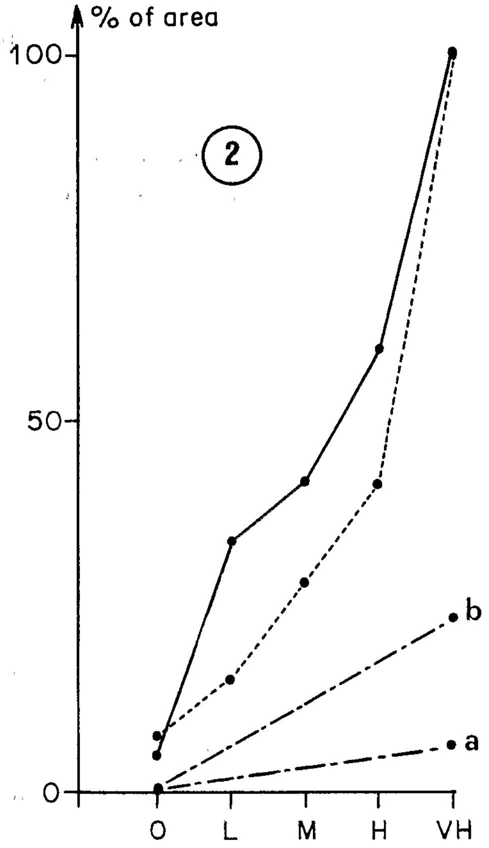
We may state our point of view on these three points together. Fig. 18 illustrating these paragraphs . is built without real data : they are given for comparison of relative effects of each proposed land-use system on the study area.

a). Level 1 : Full protection.

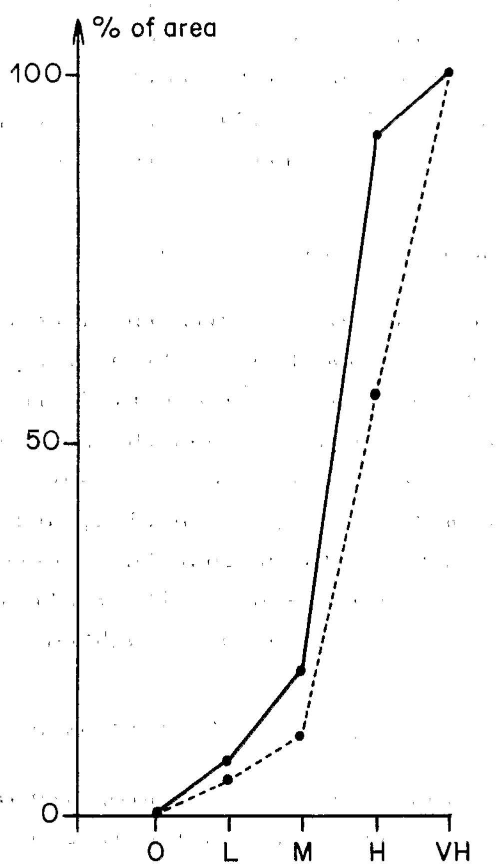
In such case each unit evolve according to its regenerative capacity. Steppic units evolve mainly through an increase of their cover (FLORET 1981). The rate of such evolution is low in the cases where units are already under

ATTRACTIVITY (1) for grazing (2) for ploughing





POTENTIAL SENSITIVITY



LEGEND

levels of proposed systems

level 1 : Full protection (not applicable here)

level 2 Pastoral regional management

level 3 Continuation of present practices

level 4 Intensification of present practices

level 5 Introduction of irrigation
(for a and b see the text)

levels of attractivity and sensitivity

O - negligible L - low

M - medium H - high

VH - very high

Figure 18 - EVOLUTION OF LEVEL OF ATTRACTIVITY AND POTENTIAL SENSITIVITY ACCORDING TO DIFFERENT LAND USE SYSTEMS AND LEVELS OF LAND USE INTENSITY

a very low level of human pressure (i.e. physiographic unit 7a), but also in the cases where the native flora and vegetation are so destroyed that it seems to have no capacity for regeneration (i.e. physiographic unit 4). Units where agricultural practices are suddenly abandoned are progressively invaded by plants of the type which gradually rebuild the native vegetation cover corresponding to the ecological conditions. This type of vegetation is sometimes difficult to visualize in the areas which are now under regular ploughing. This hypothesis is not necessarily a good way for managing the vegetation production of the ecosystem, even at medium or long term time scales.

b). Level 2 : Rangeland development and limitation of the area of ploughed fields.

The main result of such system, with rational use of rangelands, is a biological recovery and satisfactory control of degradation. This is an aspect which is rarely taken into consideration by economists.

c). Level 3 : Continuation of present practices and land-use system.

This is a realistic hypothesis according to the actual degrees of attractivity of different units for grazing (and wood cutting) and ploughing (see Table 18). It may also result in an acceleration of the clearing of more attractive areas for ploughing. An associated constant decrease of areas used for grazing produces permanent overgrazing during certain periods. Extension of cereal farming and fig plantation in addition to overgrazing and severe uprooting promote an increase of degradation processes.

d). Level 4 : Intensification of present practices.

All possible misuses of the area accumulate with the mechanization of ploughing and other agricultural practices, and the creation of watering points without limitation of size of herd or of grazing period. Regeneration of vegetation becomes low or negligible everywhere, and the progressive reduction of the yield of all types of production leads necessarily to heavy investments for reclamation, to less employment opportunities, and to limiting rural depopulation. At this level, we consider that the sensitivity will reach what we have referred to as the potential sensitivity ; all areas being at their highest level of attractivity for grazing and ploughing.

e). Level 5 : Introduction of irrigation in the test-area.

Heavy investments for introducing such level of intensity of human pressure should be conceived as rational management taking into account possibilities of irrigation. Rules of rational management of an area under grazing (creation of water points, and development of reserves of irrigated fodder crops) are considered in the same way as the extension of irrigation. This is achieved according to soils and water resources, and according to the restriction of cereal and trees farming to suitable areas which benefit from direct run-off water as a result of natural topographic conditions. This system has the same results as those of level 2, but with the highest agricultural production due to the extension of irrigation.

In reality, according to the soil resources map we can have two possibilities : (a) extension of irrigation to suitable soils without any sensitivity (i.e. a part of physiographic unit n° 13), and (b) extension also to soils which need some precautions for controlling wind deflation and possible salinization (i.e. physiographic unit n° 13).

Such approach is given here for providing possibilities to test the different levels of human pressure proposed according to the understanding of the effect of grazing and other agricultural practices on the dynamics of the ecosystem (possibilities of regeneration), and on the future of renewable resources. It is impossible, and is not our aim to propose to land planners, to choose one particular solution. Our aim is to suggest to everybody concerned with development of the study area to take into account that there are several intercorrelated factors : predictable increase of population, socio-economic changes, trends in land management, variability in dynamics of ecosystems, evolution of renewable resources, and variability of rain. It is difficult to take care of such various factors at the same time. It appears however, that an optimum level of land-use intensity should be determined on the basis of ecological considerations (in order to maximize resources, and to ensure a progressive recovery of soil and vegetation). Meanwhile, management must take care of two main facts : (a) traditional life style of local population, and (b) socio-economic needs of the population, looking for progressive improvement in their standard of living. In fact, we may propose some recommendations to farmers, planners, and scientists. These proposals are presented in Part III.

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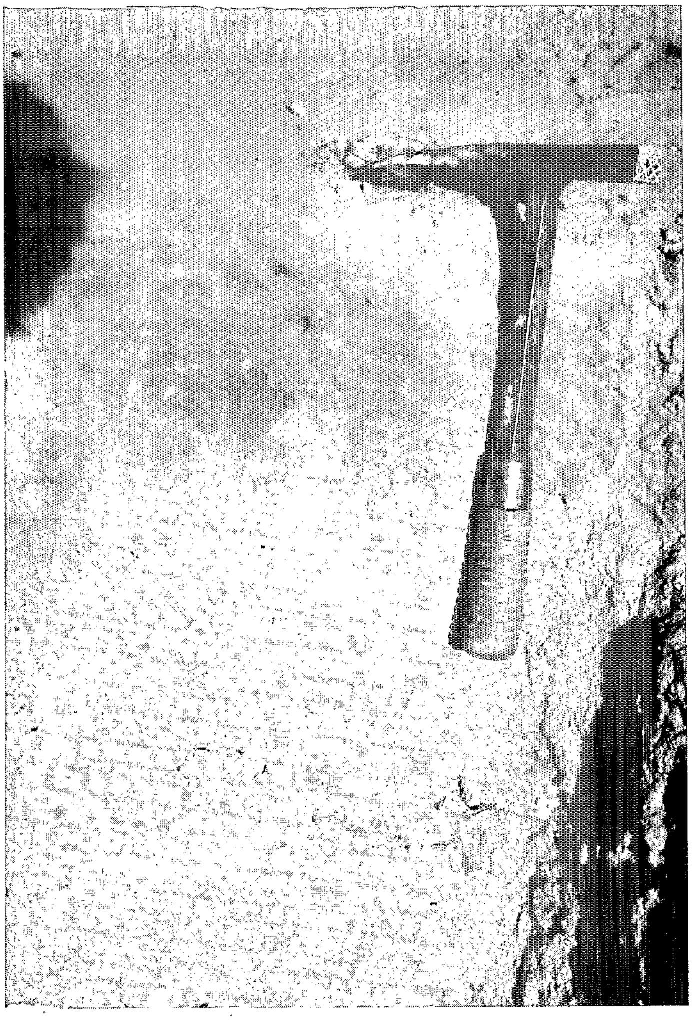
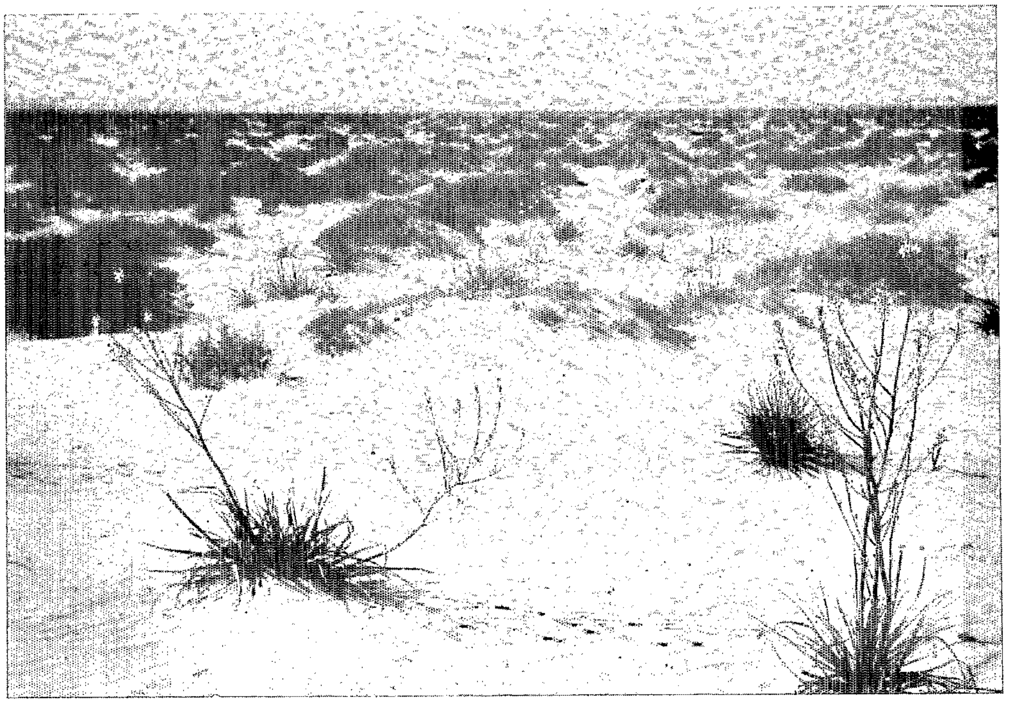


Profile of a xeric soil with calcareous incrustation.

El-Omayed - November 1981.



Rangeland of low ligneous plants in the saline depression. *Halocnemum strobilaceum* the dominant species is an indicator of salsodic soil (very saline alkali soil) and of a very shallow water-table.

El-Omayed - November 1981.

PART III

CONCLUSIONS AND RECOMMENDATIONS

This endeavour of integrated mapping of El-Omayed area is a scientific exercice that is unique to the western Mediterranean desert, and indeed to other desert areas that represent new axes for socio-economic development in Egypt. It is unique in its interdisciplinary approach, in its form of presentation that is more perceptible by decision markers, and in its in-depth analysis of the dynamics of ecological variables under the present land-use pattern. It is by no means as perfect achievement as it has been hoped for by its participants, for there is lack of consideration of some variables and superficial treatment of others due to scanty information or unaccessible means of survey. But an example is set that is worthy of persuing and extrapolating.

The lessons learned from this exercise are manifold, and the experience gained by participants furnishes an adequate background for them to extend recommendations and make conclusions which, in their view, would be useful in planning for further mapping activities and in formulating sound management and land-use plans. Some of these conclusions and recommendations are based on intuition acquired by the experience of participants ; these are of general nature and apply to the whole western Mediterranean coastal region of Egypt ; others are based on the information collected and synthesized in maps included in this publication ; these are more specific to El-Omayed and other areas of similar ecological and sociological attributes :

(1) Mapping of the distribution of ecosystems and land-use patterns is an effective tool of inventory research, one of three broad areas of research programmes for improving capacity to manage, beside functional research and management-oriented research. While functional research is concerned mainly with ecological processes and the roles of different ecosystem components, and management-oriented research is concerned with technologies of management of resources, inventory research includes surveys of ecosystems and species.

Inventories are necessary in furnishing a broad base for land resources assessment and evaluation of potential for land reclamation. Mapping of landforms, topography, soils and hydrology, as included in this publication on El-Omayed area, would help in the evaluation of water resources, its conservation, and rational utilization. However, information on run-off, a major water resource which is not treated in any detail in this publication, is scanty. It is not feasible to estimate it from climatic data, because it is related to a multitude of factors : rate of precipitation, infiltration capacity, local topography, and moisture content of surface material. These relationships need to be thoroughly studied, and detailed topographic maps need to be established before anything can be said about the management and conservation of run-off water in El-Omayed or other areas of the western Mediterranean coastal region of Egypt. Besides, the merits of ancient water conservation techniques (e.g. cisterns and karms) should be promoted for more efficient use of run-off water.

(2) Changes occur in ecosystems with time due to environmental and man-made perturbations. Monitoring of these changes is needed so that proper alternative land-use plans be made to minimize the negative effects of such perturbations. One of the common perturbations in El-Omayed, and indeed in other areas of the western Mediterranean coastal region of Egypt, is soil erosion by run-off water and by wind deflation with movement of massive bodies of sand, which are mainly due to overgrazing and overcultivation of annual crops. The misuse or overuse of renewable and non-renewable resources cannot be blamed on land users because they are acting for survival, and they often cannot realize the environmental consequences of their action, especially those of long-term effects. Experiments which demonstrate to them the rational methods of utilization of resources, and the means to offset the effects of perturbations, would be recommended.

(3) Indigenous conditions and realities should be taken into consideration in any future development plans in El-Omayed and similar areas. Instead of imposing highly developed capital-investment industrial and agricultural systems which may not be compatible with the ecological and sociological variables, development should aim at small scale agriculture, rural cottage industries, use of local materials, simple erosion control and water conservation techniques, and sources of energy based on indigenous renewable resources (e.g. biogas and solar energy).

(4) A strategy of integrated land-use systems is more supportive of subsistence economy and may provide a more adequate base for market economy than individual land-use systems. Therefore an array of production systems (e.g. rangeland system, rain-fed cropping systems, rain-fed orchard systems, local industry systems) should be encouraged at El-Omayed, and integrated with the irrigated agriculture system to the east. This integration would be particularly useful in furnishing supplemental feed for grazing animals by cultivating pasture crops in the irrigated area, especially during the drought period (June-September) and at the start of the growing season (October-December). The natural vegetation would then have an ample opportunity to regenerate and become available to grazing animals in greater phytomass during the rest of the year. Besides, the herders and the animals may be saved the difficulties of travelling to the Nile Delta every year for supplemental feed, and the risk of introducing exogenous animal diseases to the western Mediterranean region may be avoided.

(5) An ecosystem (resource system) develops in nature into a mature stage : the climax. At this stage, the ecosystem attains an equilibrium between its biotic components, particularly the vegetation, and the environmental conditions. It attains a maximum degree of stability and maximum carrying capacity of inputs of energy and nutrients, and accordingly the maximum biomass and protective ability against environmental perturbations. Arid ecosystems as those of El-Omayed, even at the climax stage, are generally of simple structure and thus are oftenly of low stability and protective ability. They are therefore more vulnerable to degradation than other ecosystems. However, when left alone, arid ecosystems stressed by environmental perturbations (such as severe drought), will usually retain their original stable and protective structure. Man-made perturbations (e.g. overgrazing, wood cutting, overcultivation of annual crops) however, often tend to simplify the structure of the ecosystem with the result of reducing its stability and its protective phytomass, and thus making it more prone to degradation. As indicated in this publication, the ecosystems of El-Omayed, and conceivably of the whole western Mediterranean region of Egypt, has been degraded to various degrees ; some are hopefully reparable and others are irreparable. In order to restore a reasonable degree of stability of these ecosystems and their protective phytomass, land-use plans should aim at simulating the structure of their climax communities. It is mentioned under "Vegetation dynamics" of this publication (section 3.1.4.3.) that climax communities of the Mediterranean coastal region of Egypt cannot be definitely determined, but the postulation is made that, in view of the local dominance of some shrubby species and the presence of remnants of others, the present vegetation is reminiscent of degraded maquis of the *Olea-Ceratonia* type. It is therefore advisable to encourage the spreading of orchards of these and other drought resistant fruit trees in the region. These will simulate the climax and will be both productive and protective. On the other hand, it may be feasible to check overgrazing, wood cutting or overcultivation of annual crops without provision for alternatives of these practices. It may be recommended that drought resistant trees and shrubs be cultivated which could serve as wind breaks, and which may provide supplementary feed for animals and fuel wood. This would serve the double purpose of meeting the demands of inhabitants, and releasing the pressure on vegetation. The vegetation would then be given the chance to regenerate and increase its cover, which would result in reduction of soil erosion by run-off water and wind, and in the increase of its infiltration and water holding capacity.

(6) The water-use efficiency of local and introduced grain and range crops, and the effect of organic fertilizers, soil texture and soil salinity on their growth are to be tested in experimental plots in order to select the most adaptable and productive crops. But care must be taken that the rapid adoption of high-yielding species of crops threatens the existence of hardy native species. These native species could prove crucial to the maintenance of the high-yielding species which are proving susceptible to diseases and

other severe environmental perturbations. The achievement of high-yielding species must, therefore, be complemented by breeding programmes to develop and maintain their resistance and adaptability. Local species may be the key to accomplish this ; they have been exposed to local environment for centuries and have developed genetic traits that contribute better adaptation to local environment, which could be transferred to new high-yielding species. Reseeding experiments are also recommended of local palatable species which, due to overgrazing that dominated the region for centuries, became almost extinct. Sample areas are also to be protected to enhance the regeneration of these species, and to provide a stock of their seeds. New tillage methods and crop rotation (e.g. grain and legume crops) are also to be tested in comparison with traditional methods.

(7) A notable change due to intensive irrigated agriculture to the east of El-Omayed was the acceleration of the rythm of transformation from subsistence to market economy, so that the whole region, particularly the newly reclaimed areas, became inserted into the market economy of the whole country. This had for reaching implications on the socio-economy of the region that need to be thoroughly evaluated. The rural management plan in these irrigated areas, for example, depended mainly on the mobilization of labour force from other areas. It would be advisable that such plan takes an integrated form so that human resources are allocated not only to irrigated farming but also to other activities of socio-economic importance to the whole region, such as animal husbandry , local industries and tourism.

(8) The remarkably high calcium content of the soils at El-Omayed and most of the western Mediterranean region of Egypt is reflected in a much higher than average content in range plants. Getting rid of excessive calcium represents a load on grazing animals. A study should be carried out in order to identify adequate means of reducing calcium absorption in the guts of animals, as by increasing the level of potassium in their diet, and adjusting the calcium : phosphorus ratio within the recommended range (2-3:1).

(9) The above-mentioned conclusions indicate the need for further action on the side of research workers, planners and land users, in order to be able to develop land-use strategies which ensure a sustainable level of production and which keep a high degree of compatibility between ecological, technological and sociological variables. Facilities are needed for persuing the functional and inventory research started in SAMDENE and REMDENE projects, and for initiating management oriented research as field experiment for testing new land-use plans and innovative technologies, and for monitoring their effects. Planners and land users need more support for the application of rational management plans in the form of ample supply of necessary equipment for farming operations and for the initiation of small cottage industries, seeds, useful trees and shrubs, and guidance for the proper use of these supplies. There is also an urgent need to bridge the gaps between research

workers, planners and land-users, to that research works would conceive priorities of research to provide basic information for land-use plans, and that the planners and land-users would perceive the ecological consequences of their plans. Permanent contacts therefore, should be established between governmental authorities, inhabitants and research institutes, and training courses, and meetings should be hed periodically for acheiving these goals.

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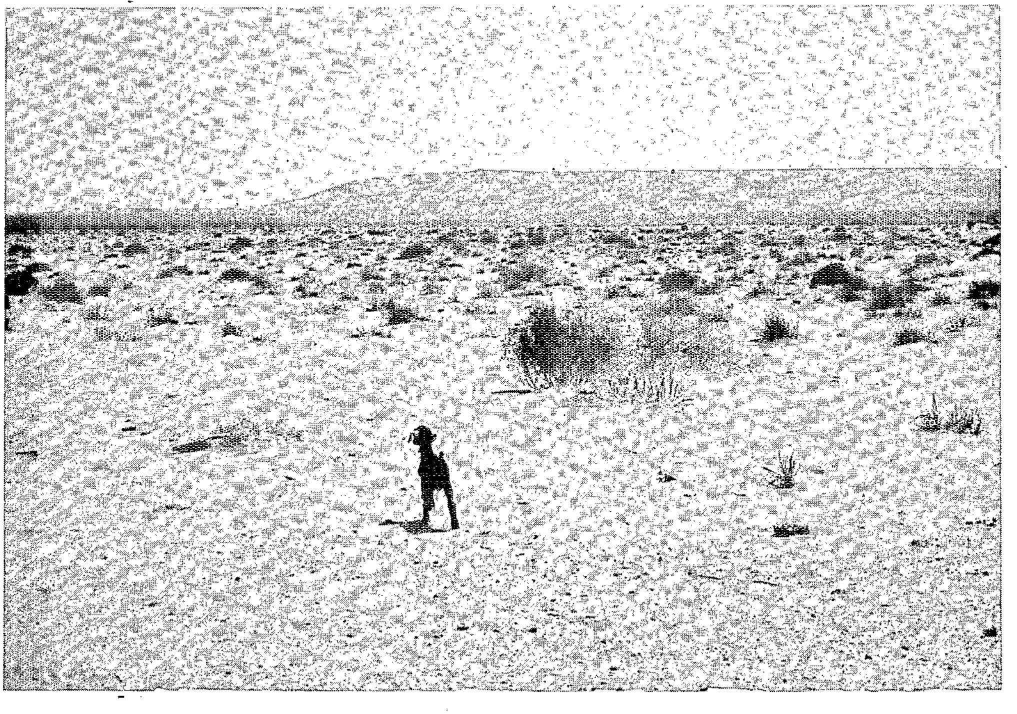
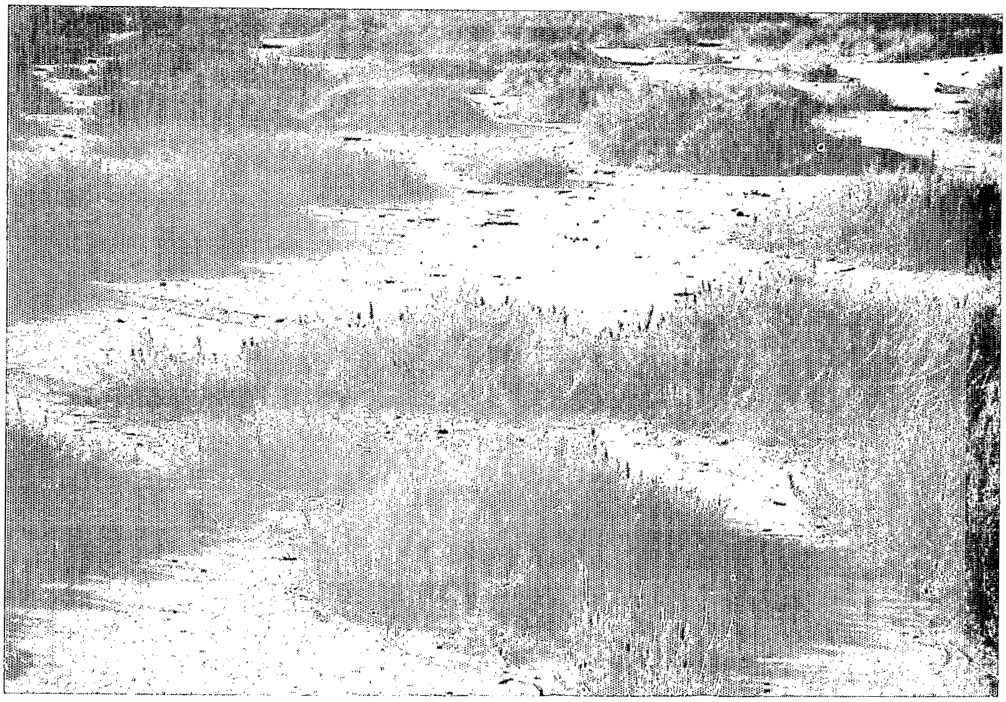


Grazing area on the sandy glacis of the northern slope of Khashm El Eish.

El-Omayed - April 1982.

Wind erosion and sand deposit in an orchard of fig trees.

El-Omayed - November 1981.



Rangeland of low ligneous plants in the saline depression. Phytoecological association with *Limoniastrum monopetalum* and *Asphodelus microcarpus* on salsodic soil with a water-table more than one meter deep.

El-Omayed - April 1982.

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